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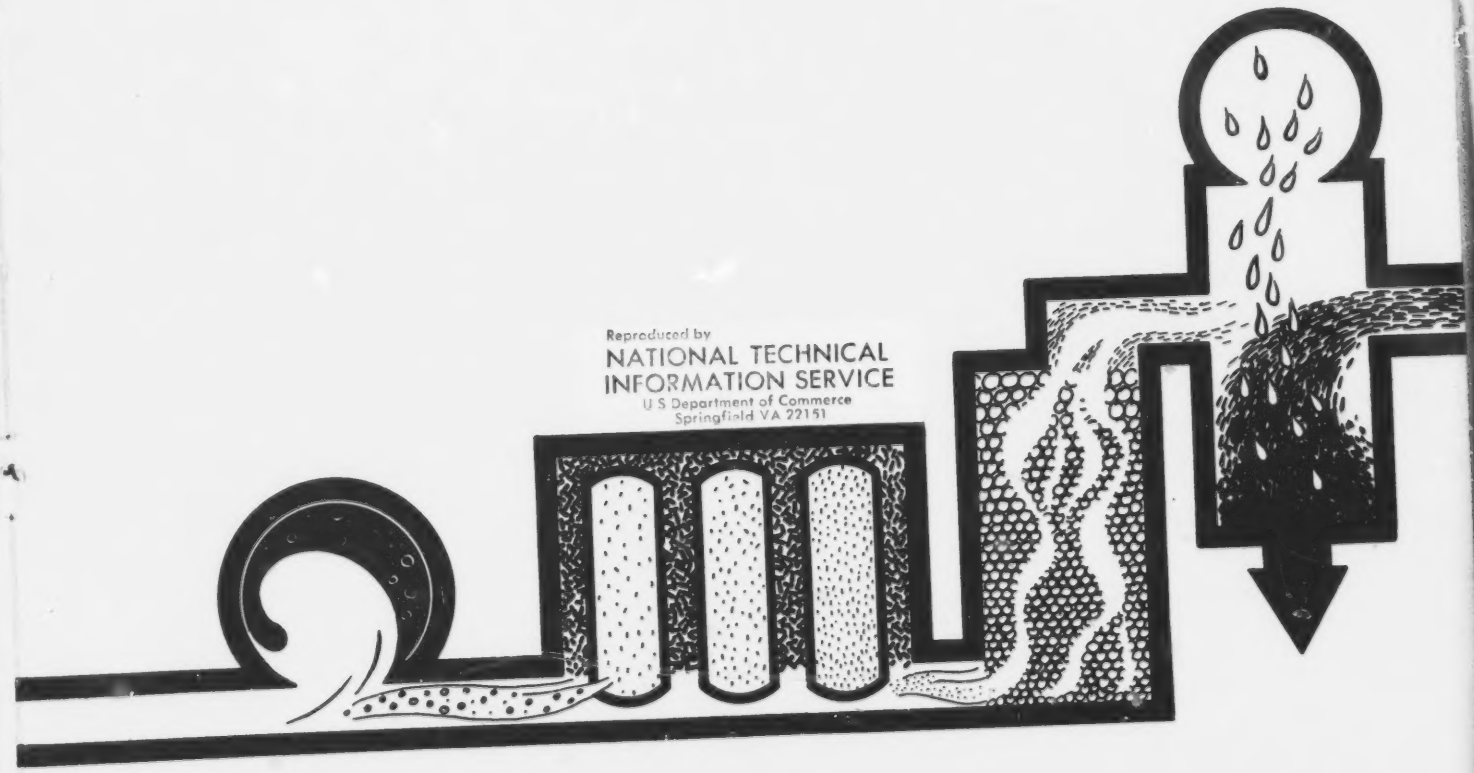
APPLICATION OF ROTATING DISC PROCESS TO MUNICIPAL WASTEWATER TREATMENT



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APPLICATION OF ROTATING DISC PROCESS

TO

MUNICIPAL WASTEWATER TREATMENT

by

Autotrol Corporation
Bio-Systems Division
5855 North Glen Park Road
Milwaukee, Wisconsin 53209

for the

OFFICE OF RESEARCH AND MONITORING

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ABSTRACT

A prototype package plant incorporating the rotating disc wastewater treatment process was tested on municipal wastewater at the Village of Pewaukee, Wisconsin, to evaluate its treatment capabilities and establish guidelines for operation and testing of a full-scale rotating disc demonstration plant soon to be put into operation at Pewaukee. The package plant included a rotating bucket feed mechanism, ninety-one 1.75-meter diameter discs divided into two stages, and a secondary clarifier with a sludge-removal mechanism. Variables tested included hydraulic loading, rotational disc speed, sludge recycle, and wastewater temperature as it varied with climatic conditions.

At a hydraulic loading of 1.5 gpd/ft^2 of disc surface, the package plant achieved 87% removal of BOD and 80% removal of suspended solids to yield an effluent of 20 mg/l BOD and suspended solids when treating effluent from the existing primary clarifier. At the same hydraulic loading, 85% removal of ammonia nitrogen was obtained to yield an effluent of 3.5 mg/l.

Low maintenance requirements and low power consumption were demonstrated by the rotating disc process during the test program.

This report was submitted in fulfillment of Project 17050 DAM, Contract 14-12-810, under the sponsorship of the Environmental Protection Agency.

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SECTION I

CONCLUSIONS

1. The rotating disc method of wastewater treatment provides a compact, highly efficient means of obtaining BOD, suspended solids, and ammonia nitrogen removal from domestic wastewater.

2. The simplicity of the process and its mechanical equipment result in a very low requirement for maintenance.

3. Low maintenance requirements and low power consumption make the rotating disc process well suited to package plant applications and for fulfilling wastewater treatment needs in remote areas.

4. The rotating disc method of wastewater treatment can achieve in excess of 90% BOD and suspended solids removal and produce effluents of less than 15 mg/l BOD and suspended solids when operated at the proper hydraulic loading.

5. Carbonaceous BOD removal by the rotating disc system is first order with respect to BOD concentration up to approximately 90% reduction.

6. At treatment levels above 80% BOD removal and effluents below 35 mg/l BOD, approximately 50% of the remaining BOD is carbonaceous and 50% nitrogenous.

7. Ammonia nitrogen removal by the disc system is first order with respect to ammonia nitrogen concentration. Removals in excess of 95% are achieved, and effluents of less than 0.5 mg/l ammonia nitrogen are produced at the proper hydraulic loading.

8. Because carbonaceous BOD removal and ammonia oxidation are first order, the primary design criterion for rotating disc systems is hydraulic loading as gpd/ft^2 of surface covered with biomass. Peripheral velocity of the rotating discs, and the number of stages of discs are also important design criteria.

9. The optimum rotational disc speed for BOD, suspended solids, and ammonia nitrogen removal is approximately 58 ft/min peripheral velocity (3.2 RPM on the test unit).

10. BOD and suspended solids removal are unaffected by wastewater temperatures above 50°F. Ammonia nitrogen removal is unaffected by wastewater temperatures above 54°F. Below these temperatures, lower hydraulic loadings are required for a given degree of treatment.

11. Power consumption at the optimum disc speed is 0.2 Hp-Hr/lb. BOD removed when providing 87% BOD removal and an effluent of 20 mg/l BOD.

12. BOD removal by the rotating disc system during this investigation compares well to that obtained during a previous investigation and demonstrates first order behavior over the range of 147 to 426 mg/l BOD domestic wastewater.

13. BOD removal during this investigation does not compare well to European experience. The reason for this is thought to be the wider disc spacing used on European disc systems, which yields a longer retention time at a given hydraulic loading and therefore a higher degree of treatment.

14. Disc units which are operated in tanks closely contoured to the shape of the discs should have disc spacing greater than 0.5 inch, surface to surface, to obtain full utilization of the surface area.

SECTION II

RECOMMENDATIONS

This investigation has allowed the evaluation of the rotating disc method of wastewater treatment. During the course of the testing, several aspects of rotating disc process operation were revealed which warrant further investigation. Most of these were beyond the scope of the present investigation or could not be tested with the available test equipment. This testing was conducted on a two-stage disc unit. European experience indicates that three and four-stage operation allows significantly higher hydraulic loading for equal treatment. Additional testing on a four-stage disc system at various hydraulic loadings should be conducted to verify the improved performance.

The disc spacing of the test unit in this investigation yielded a liquid holding capacity less than that of European disc systems. The lower retention time occurring at a given hydraulic loading resulted in a lower degree of treatment than in European systems. Additional testing at various disc spacings will be required to determine the optimum disc spacing which will maximize the effectiveness of the disc surface area.

All testing in this investigation was under constant flow conditions. Diurnal flow variations and flow patterns encountered in other domestic wastewater applications should be tested to determine their effect on treatment efficiency by tne disc process.

Because both stages of discs in this investigation were mounted on the same shaft and driven by a single drive mechanism, the optimum rotational velocity determined applies only when all discs in the system are rotated at the same velocity. In a multi-stage disc plant, there is probably an optimum rotational velocity for each successive stage of discs as the wastewater undergoes a progressively increasing degree of treatment. Additional studies to optimize the rotational speed of each stage in a multi-stage disc system would improve the already low power consumption of the disc process.

Sludge production measurements from this investigation were erratic. Additional sludge production measurements should be made on a multi-stage disc system to more accurately determine its sludge production at various degrees of treatment.

Sludge recycle rates tested in this investigation were too low to affect any operating or performance parameters of the system. Additional studies at higher recycle rates should be conducted to determine the effect of this process variable.

Biological solids generated by the rotating disc appear to have characteristics which would make them conducive to mechanical separation, such as sand filtration or microscreening. Tests should be conducted on both secondary clarifier effluent and rotating disc mixed liquor to establish the technical feasibility of mechanically clarifying rotating disc process effluents.

It has been demonstrated in this investigation that any desired degree of ammonia nitrogen oxidation can be achieved in the disc system by operating at the proper hydraulic loading without adjustment of normal municipal wastewater pH. It would be of value to determine whether ammonia nitrogen oxidation rates could be increased in the disc system by chemically adjusting the pH of the mixed liquor of disc stages where nitrification was occurring.

Many of the above recommendations on further testing of rotating disc systems can be incorporated into the testing and evaluation program for the rotating disc demonstration plant at Pewaukee, Wisconsin. This will be done to the extent possible within the scope of the evaluation.

SECTION III

INTRODUCTION

The rotating disc process is a secondary biological wastewater treatment system. It has been used for wastewater treatment in Europe for 12 years. At present, there are over 600 commercial installations, primarily in West Germany, France, and Switzerland, ranging in size from 12 people to 100,000 population equivalent and treating a variety of domestic and industrial wastes. Research and development work has been conducted on this process in the United States since 1965, and several commercial installations are now in operation and under construction in this country.

The object of this investigation was to test a rotating disc unit under field conditions with municipal wastewater and evaluate treatment levels at various rates of hydraulic loading.

The results of the tests were to be compared to previous testing and used to establish guidelines for the testing and evaluation of a 400,000-GPD rotating disc treatment plant constructed with Environmental Protection Agency demonstration grant funds at the Village of Pewaukee, Wisconsin.

SECTION IV

PROCESS DESCRIPTION

The system consists of a number of large-diameter, lightweight plastic discs, which are mounted on a horizontal shaft and placed in a semi-circular shaped tank. The discs are rotated while approximately one-half of their surface area is submerged in the wastewater. Immediately after startup, organisms present naturally in the wastewater begin to adhere to the rotating surfaces and multiply until, in about one week, the entire surface area of the discs is covered with an approximately 1/16 to 1/8 inch thick layer of biomass.

In rotation, the discs carry a film of wastewater into the air where it trickles down the surface of the discs and absorbs oxygen. Organisms in the biomass then remove both dissolved oxygen and organic materials from this film of wastewater. As the discs continue rotation through the bulk of the wastewater in the tank, further absorption of dissolved oxygen and organic materials is performed by the biomass. Operating in this manner, the rotating discs serve several functions: provide a medium for the development of a fixed biological growth, contact of the growth with the wastewater, and aeration of the wastewater. Shearing forces exerted on the biomass as it is passed through the wastewater cause excess biomass to slough from the discs into the mixed liquor. This prevents clogging of the disc media and maintains a constant microorganism population on the discs. The mixing action of the rotating discs keeps the sloughed solids in suspension until the treated wastewater carries them out of the disc sections for separation and disposal.

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SECTION V

DESCRIPTION OF TEST UNIT

Figure 1 shows the prototype rotating disc package plant used for the investigation. It consists of a wet well and rotating bucket feed system, a two-stage rotating disc treatment system, and a secondary clarifier with a rotating sludge scoop, all incorporated into a single, semi-circular shaped tank. This package system is intended to operate in conjunction with primary treatment and sludge disposal facilities.

In operation, primary treated wastewater flows into the wet well, where a series of buckets, attached to the same shaft that rotates the discs, deposit it via a trough into the first stage of discs (see Figure 2). An overflow connection maintains a constant level in the wet well and, therefore, a constant feed rate. At a given disc speed the feed rate is varied by changing the number of feed buckets.

The disc section contains ninety-one 1.75-meter diameter discs, which are divided into two approximately equal-size stages. The stages are divided by a bulkhead and connected by a trough, so that they operate in series. The discs, which are molded from expanded polystyrene beads, are 0.5 inch thick and spaced on 1.0-inch centers. Figure 3 shows construction features of the type of discs used in the package plant. There are eleven intrinsically molded bosses on the surface of each disc, which act as spacers. Eight of the bosses are located near the perimeter of each disc, two are near the center, and one forms the hub of the disc. Rods pass through holes in the bosses and are attached to spider-like arms located at each end of a stage of discs. The arms are attached to the main shaft, which passes through all the discs in the package plant. The system of main shaft, spider-arms, connecting rods, and bosses uniformly distributes the driving torque applied to the discs and provides support to the discs as they are rotated through the wastewater. The type of disc and support structure described here has been used in Europe for 12 years without any reported mechanical failure of the discs.

Power is supplied to the discs by a 1/6-hp motor, which is mounted on a structure between the disc section and the secondary clarifier. Power is transmitted to the main shaft by the friction of a chain passing over a circular metal strip, the same diameter as the discs and mounted on the last set of spider arms. See Figure 4.

Mixed liquor passes from the last stage of discs into the clarifier through an opening in the bulkhead separating them. To minimize the effects of turbulence, the opening is located in the corner of the clarifier; and a pipe directs the flow against the bulkhead beneath the water level.

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Figure 1
Prototype Rotating Disc Package Plant

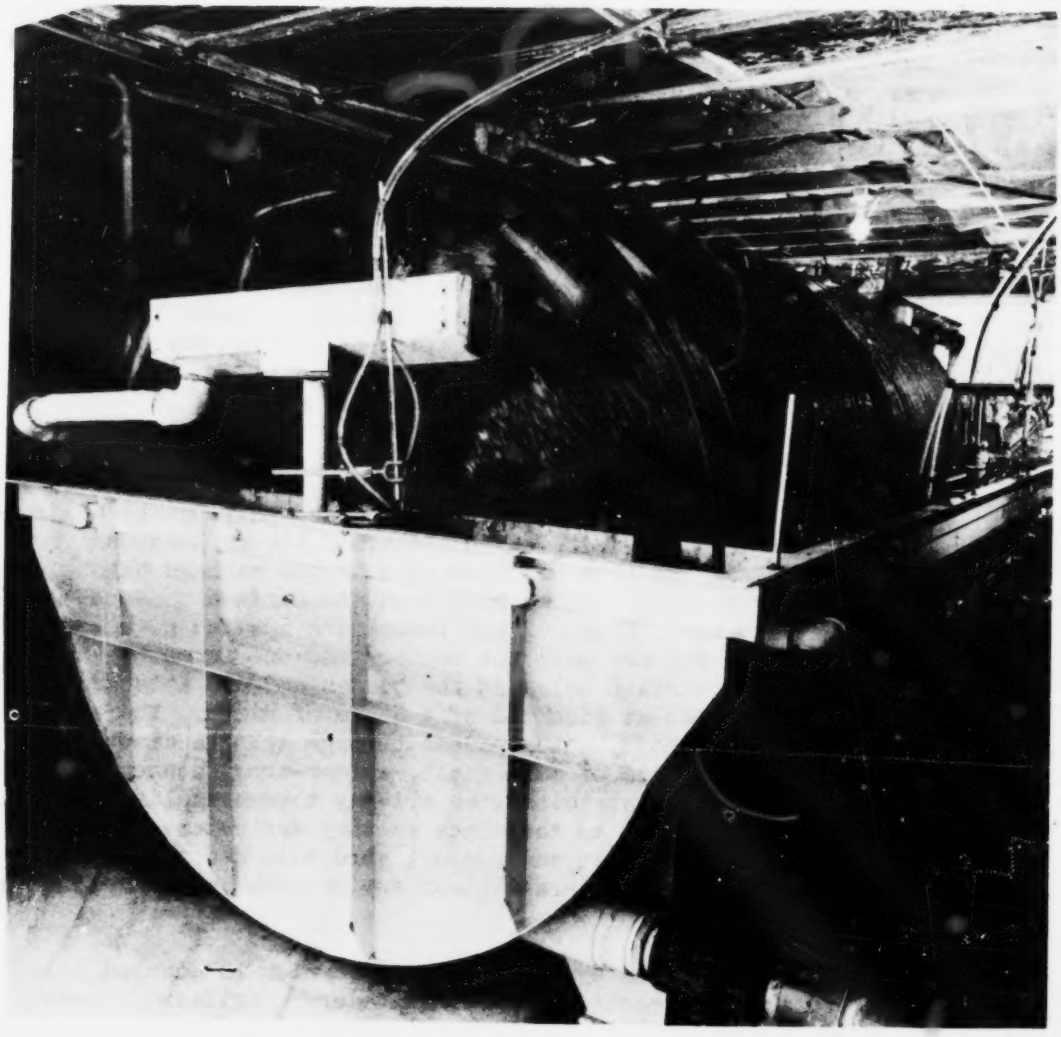
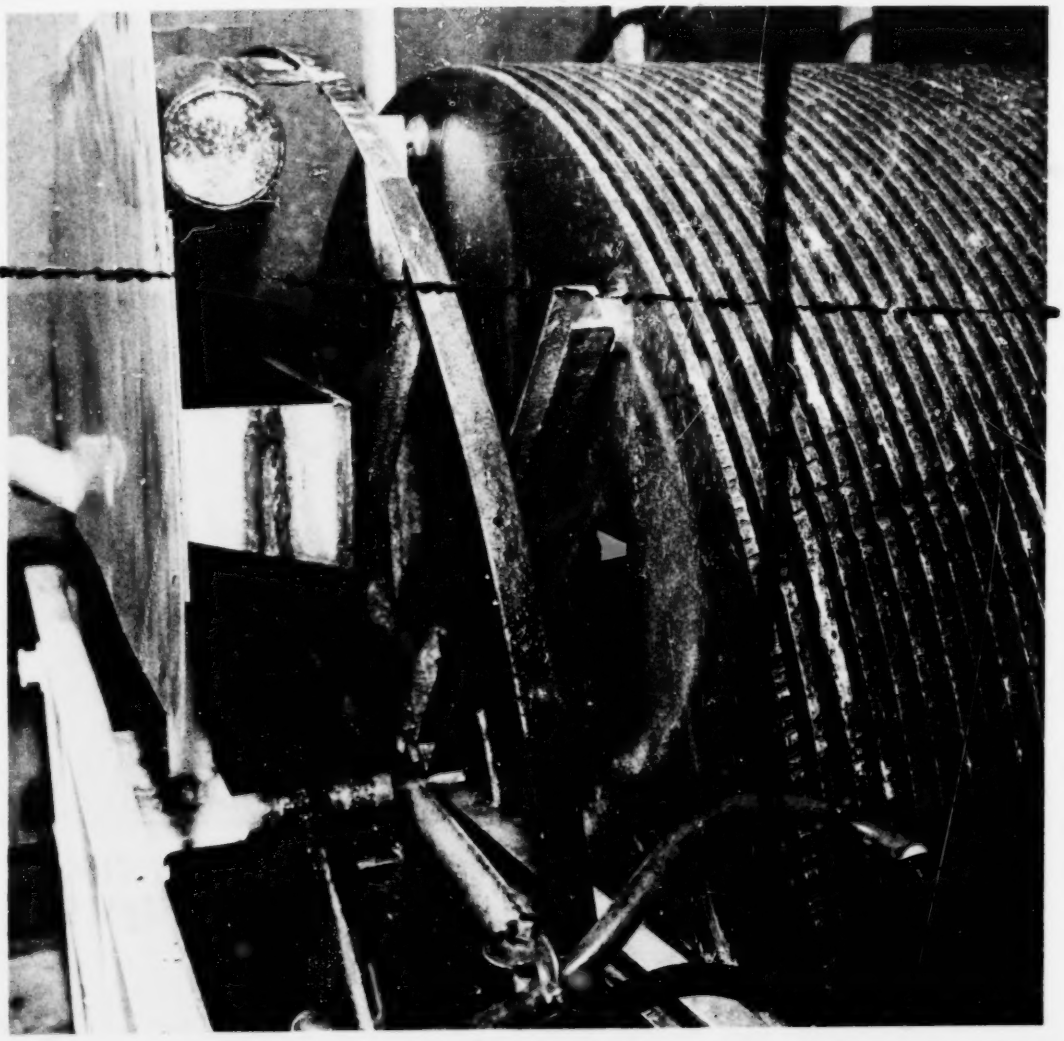
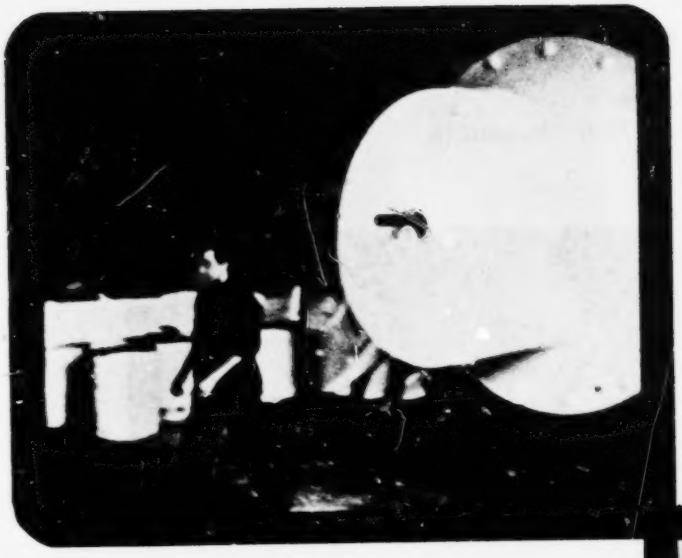


Figure 2
Rotating Bucket Feed Mechanism





SIZES AVAILABLE
6 FT. AND 10 FT. DIA.

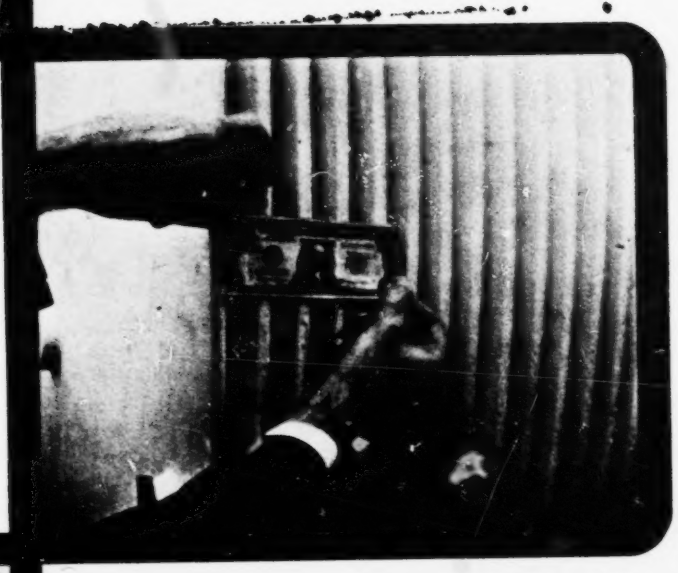
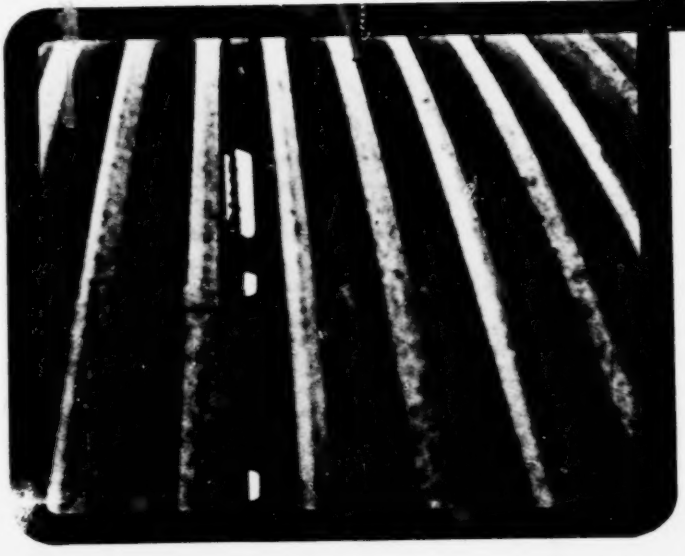


Figure 3

Molded Polystyrene Discs

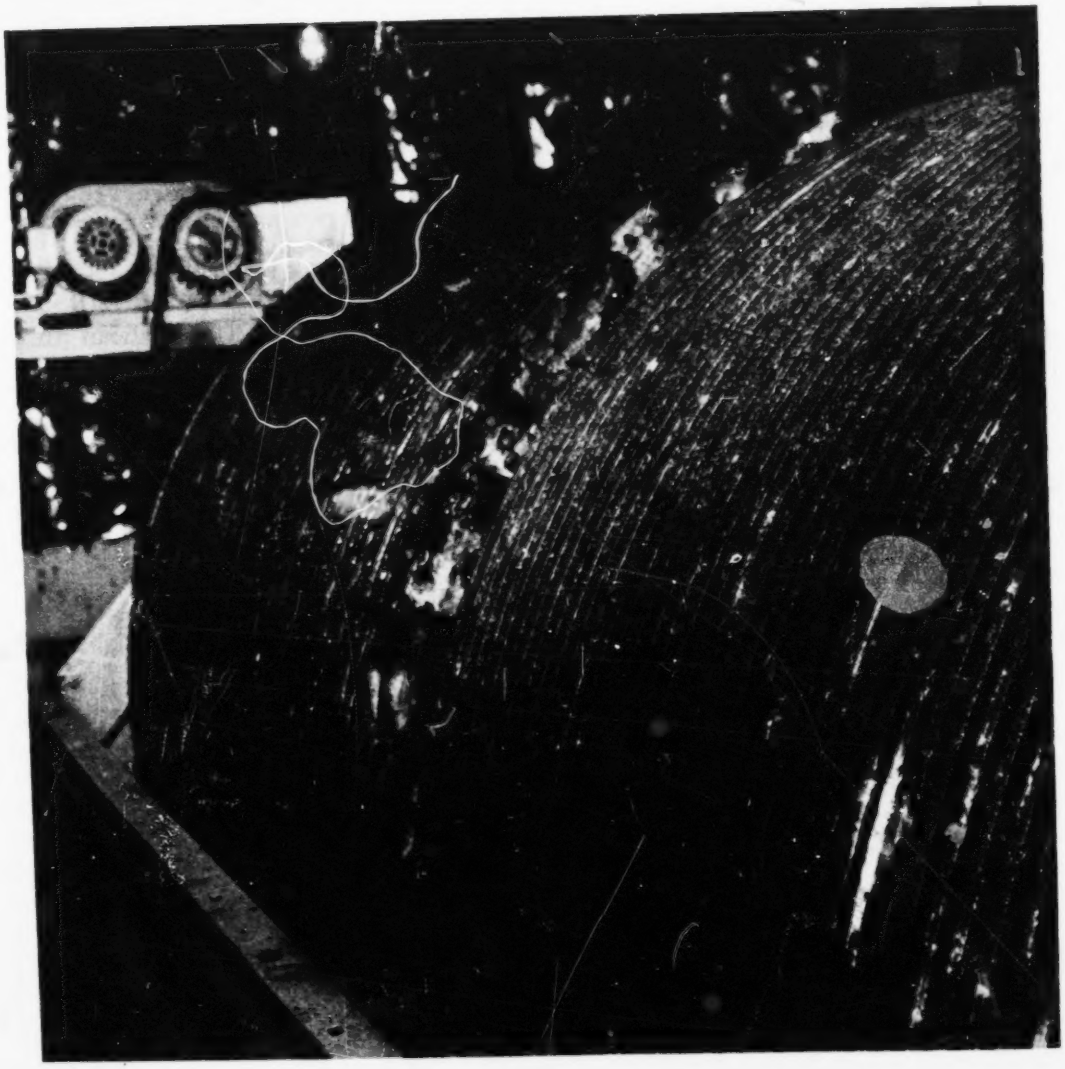
MOLDED POLYSTYRENE DISCS

DISC–NOMINAL
THICKNESS OF ½ IN.



RIGIDITY MAINTAINED
BY MOLDED SPACERS

Figure 4
Two-Stage Disc Assembly with Drive Motor



Settled sludge is removed by the rotating scoop and reservoir system shown in Figure 5. The scoop system is driven independently at 2 to 6 rph to allow adjustment for sludge removal requirements. As the empty reservoir passes into the water, it draws sludge up through the scoop and hollow connecting arms until it is full. Then, as the reservoir leaves the water, it empties the sludge through hollow support arms into the hollow drive shaft. From there it flows out of the system for treatment and disposal. Clarifier overflow passes over a weir to an outlet located in the opposite corner from the inlet.

The clarifier has an operating volume of 455 gallons and an overflow area of 32 square feet. The overall size of the package unit is approximately 15 feet long, 6.5 feet wide, and 6.5 feet high. It has a design capacity of 8,000 gpd.

Additional details on the test unit are listed in Table I and shown in Figure 6.

Figure 5
Secondary Clarifier and Sludge Scoop

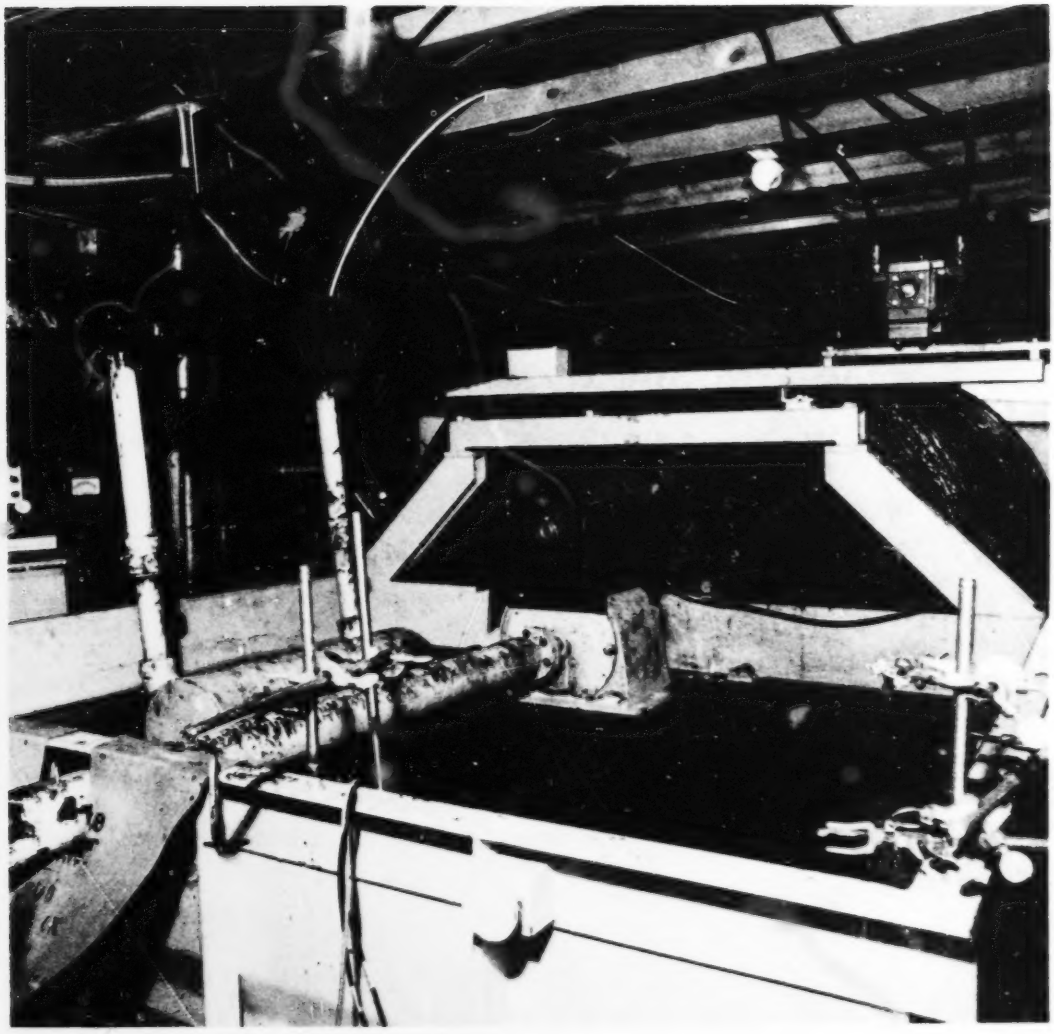


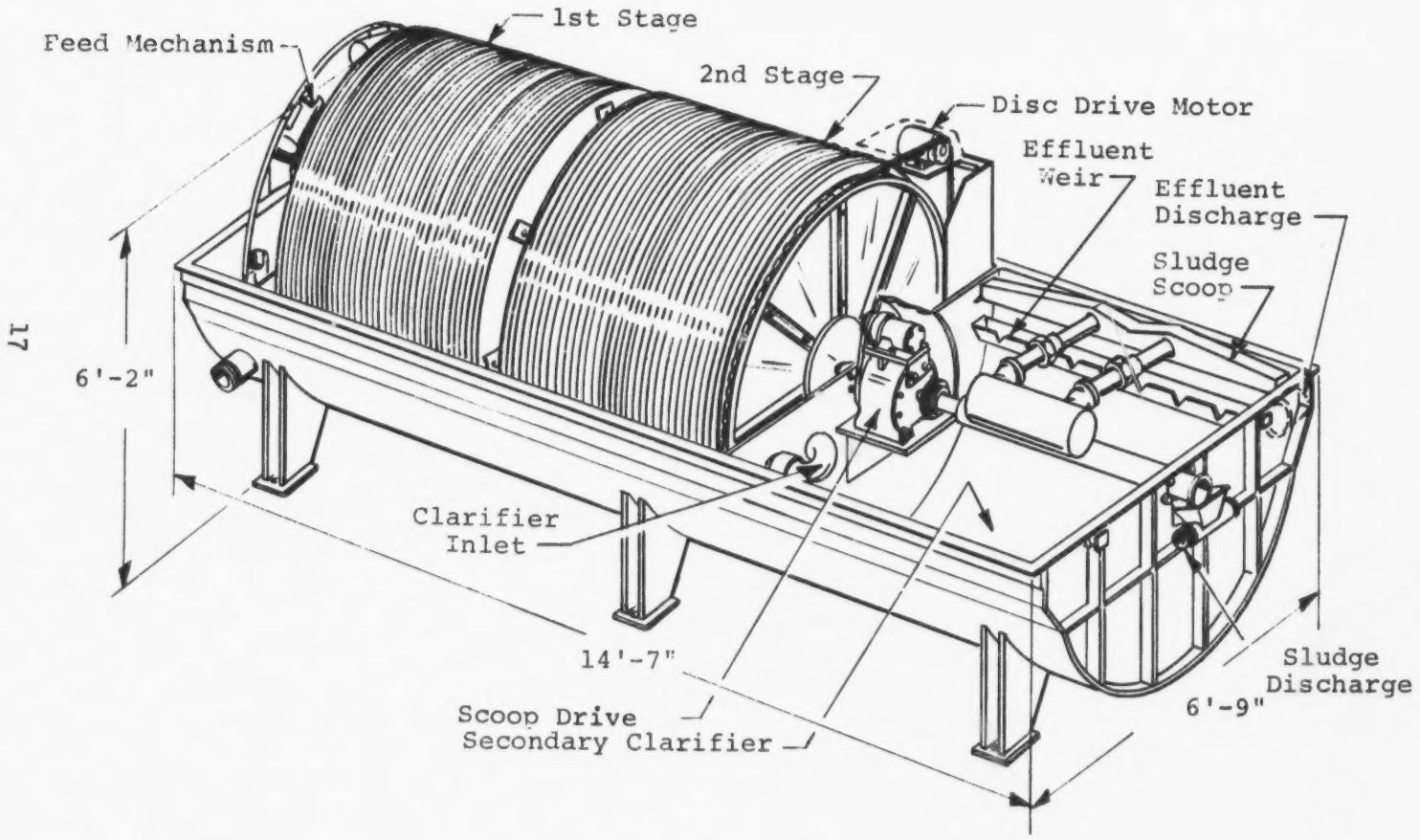
TABLE 1

Rotating Disc Unit Specifications

1.	Disc Velocity	2 - 5 RPM
2.	Disc Diameter	5.74 ft. (1.75 m)
3.	Number of Stages	2
4.	Number of Discs - Stage 1, 45	
	- Stage 2, 46	
	Total:	91
5.	Total Effective Disc Area	4,600 ft^2 (428 m^2)
6.	Disc-Tank Volume, Gross	700 gal. (2.65 m^3)
	Net	280 gal. (1.06 m^3)
7.	Submerged Volume of Discs	420 gal. (1.59 m^3)
8.	Clarifier, Surface Area	32 ft^2 (2.98 m^2)
9.	Clarifier, Volume	455 gal. (1.73 m^3)
10.	Clarifier, Weir Length	5 ft. (1.52m)

* Based upon a bio-mass thickness of 0.1 inches (2.5 mm)

Figure 6
Rotating Disc Package Plant Details



SECTION VI

TEST PROGRAM

The package plant was installed in a garage-like structure to protect it from wind, heavy precipitation, and freezing temperatures and was located within the grounds of the treatment plant of the Village of Pewaukee, Wisconsin. Figure 7 shows the location of the test unit within the treatment plant grounds.

The present Pewaukee treatment plant is rated at 0.3 MGD and includes an uncovered trickling filter, primary and secondary clarifiers, an anaerobic digester, and sludge drying beds. Secondary sludge is drained into the wet well, usually during night hours when low flows are experienced. Sludge from the primary clarifier is normally pumped to the digester twice daily. Digester supernatant is returned to the wet well during these pumping periods. The primary clarifier effluent employed in this investigation, therefore, contained unknown amounts of anaerobic digester supernatant and trickling filter sludge.

Tests were begun in November, 1969, and conducted for 6 months under the contract. At its own expense, Autotrol Corporation extended the test period to October, 1970, to provide a full year of operating data and allow a more complete study of the process. During the year of operation, the primary effluent had the characteristics shown in Table 2.

TABLE 2

Average Wastewater Characteristics

	mg/l
BOD	147
Suspended Solids	128
COD	323
Ammonia Nitrogen	18.2
Kjeldahl Nitrogen	28.9
Phosphorus	11.7
Temperature, °F	55

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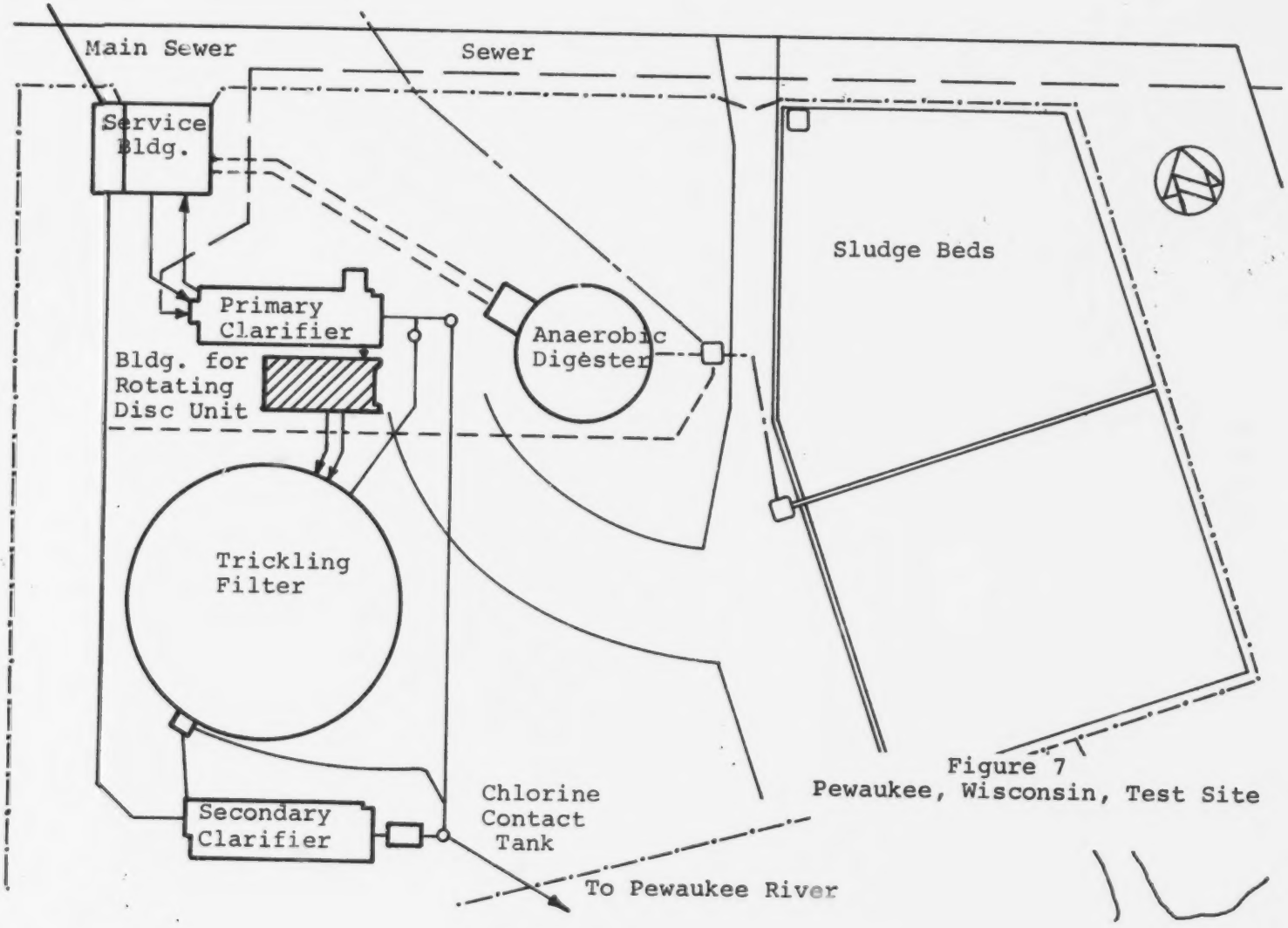


Figure 7
Pewaukee, Wisconsin, Test Site

The test unit was connected to the overflow of the existing primary clarifier. An overflow piping arrangement was used in the wet well of the test unit to obtain a constant depth of wastewater which maintained constant feed rates. Variables investigated included hydraulic loading of 50 to 920 gph, rotational disc speed of 2 to 5 rpm, sludge recycle of 1 and 2% of wastewater flow, and wastewater temperature as it changed with the climate.

A relatively wide range of mixed liquor temperatures was encountered in this investigation. Lower temperatures are believed to be related to the amount of infiltration in the Pewaukee sewerage system during spring periods of thawing and rainfall.

Since the experimental flow rates were relatively low compared with the total Pewaukee plant flow, all discharge lines from the test facility were directed to the existing trickling filter. These included wet well overflow, effluent, and secondary clarifier sludge. Sludge was discharged by gravity from the clarifier into a 50-gallon drum. A sump pump transferred the sludge to the effluent discharge line connecting the test unit with the trickling filter.

When tested, recycling of sludge was accomplished by a peristaltic pump connected to the base of the 50-gallon sludge drum. This pump was actuated about 10 minutes per hour by an automatic timer and delivered the recycled waste sludge to the inlet of the first stage of discs.

Four (4) NAPPE-PORTA-POSITER samplers were installed to take twenty-four hour composite samples at the following four sampling points: the wet well, the first stage mixed liquor, the second stage mixed liquor, and the effluent from the secondary clarifier. When it was not possible to obtain a twenty-four hour composite sample, a grab sample was taken for analysis. In June, 1970, of the test period, these samplers were replaced with samplers which were equipped with refrigeration.

Samples were taken, and laboratory analyses were performed as indicated in Table 3. Procedures employed in these analyses were in accordance with the "Standard Methods for The Examination of Water and Wastewater," Twelfth Edition, 1965, APHA.AWWA. WPCF.

TABLE 3

Sampling and Analysis Program

Analysis	Sampling Points *
Temperature	B
pH	A, D
Dissolved Oxygen	A, B, C, D
Chemical Oxygen Demand	A, D
Sludge Solids	D
Settleable Solids	A, B, C, D
Total Suspended Solids	A, B, C, D
Volatile Suspended Solids	A, B, C, D
Biochemical Oxygen Demand	A, D
Total Phosphorus	A, B, C, D
Dissolved Phosphorus	A, D
Ortho-Phosphorus	A, B, C, D
Kjeldahl Nitrogen	A, B, C, D
Ammonia Nitrogen	A, B, C, D
Nitrate Nitrogen	A, B, C, D
Nitrite Nitrogen	A, B, C, D

* A = Wet Well, B = First Stage Mixed Liquor, C = Second Stage Mixed Liquor, D = Effluent from Secondary Clarifier.

SECTION VII

TEST RESULTS

The test unit was operated for a period of several weeks under each set of operating conditions. Data collected each day is presented in the Appendix. Arithmetic averages of the data collected under each set of operating conditions are also presented in the Appendix. The averages were used for all data correlations. The majority of the following correlations are presented as a function of hydraulic loading, which has been found to be the primary design criterion for the rotating disc process. Hydraulic loading is measured as the amount of wastewater flow per unit of time per unit of surface area covered by biological growth.

BOD Removal

Figures 8 and 9 show percent removal and effluent concentrations for BOD as a function of hydraulic loading. Retention time in the disc sections is also shown for purposes of reference.

Separate loading curves are drawn for the disc speed range of 3.2 to 5 RPM and for 2 RPM for wastewater above 50°F, and 5 RPM for wastewater below 50°F. The data points at 3.2 RPM and 4.3 to 5 RPM appear to follow the same correlation, so a single curve was drawn to include this entire range of disc speed. This was done for all data correlations at wastewater temperatures above 50°F.

At a hydraulic loading of 1.0 GPD per ft^2, 90% BOD removal was obtained with this two-stage system. An effluent BOD concentration of 20 mg/l was obtained at a loading of 1.5 GPD/ft^2, which represents 90% overall removal when including primary treatment on an average municipal wastewater. When treatment requirements call for just roughing treatment, the disc system can obtain 70% removal at a loading of 4.8 gpd/ft^2.

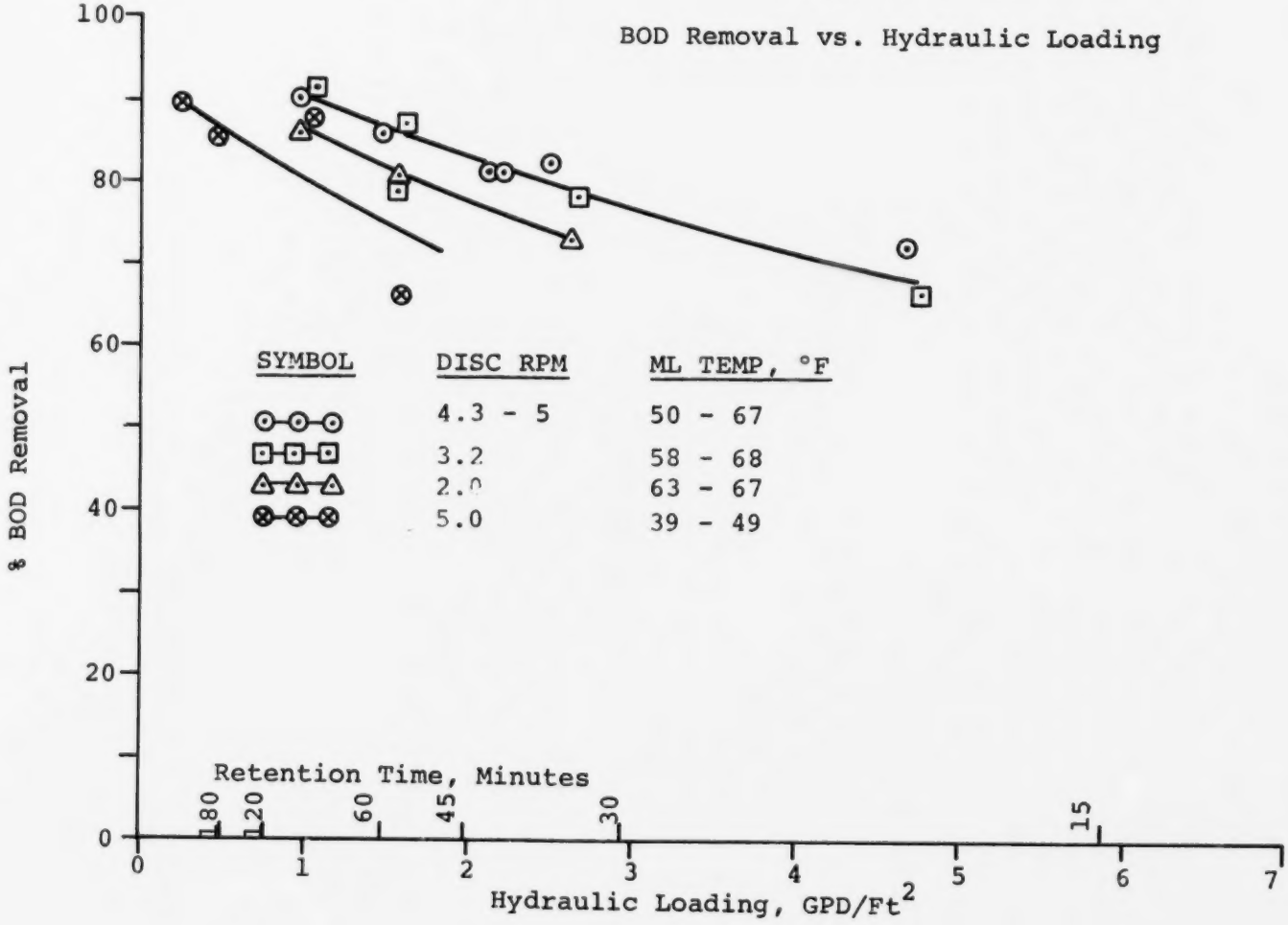
Rotational disc speed had a significant effect on treatment efficiency. While 3.2 and 4.3-5 RPM gave very similar performance, 2.0 RPM gave significantly lower performace over the entire range of hydraulic loads tested. The reasons for this are the increased efficiency of mixing within a stage, more effective contact between the biomass and the wastewater, and increased aeration rate at the higher speeds.

Wastewater temperature does not appear to affect BOD removal above 50°F. Below 50°F, BOD removal rates decrease significantly; however, equal treatment can be obtained at reduced hydraulic loading.

Figure 10 reveals some aspects of the kinetics of BOD removal in the disc system. Five-day BOD removal (solid line) is close to first order up to 70 to 80% reduction. At higher degrees of treatment, the reaction rate decreases considerably. This can be explained by the data in Table 4.

Figure 8

BOD Removal vs. Hydraulic Loading



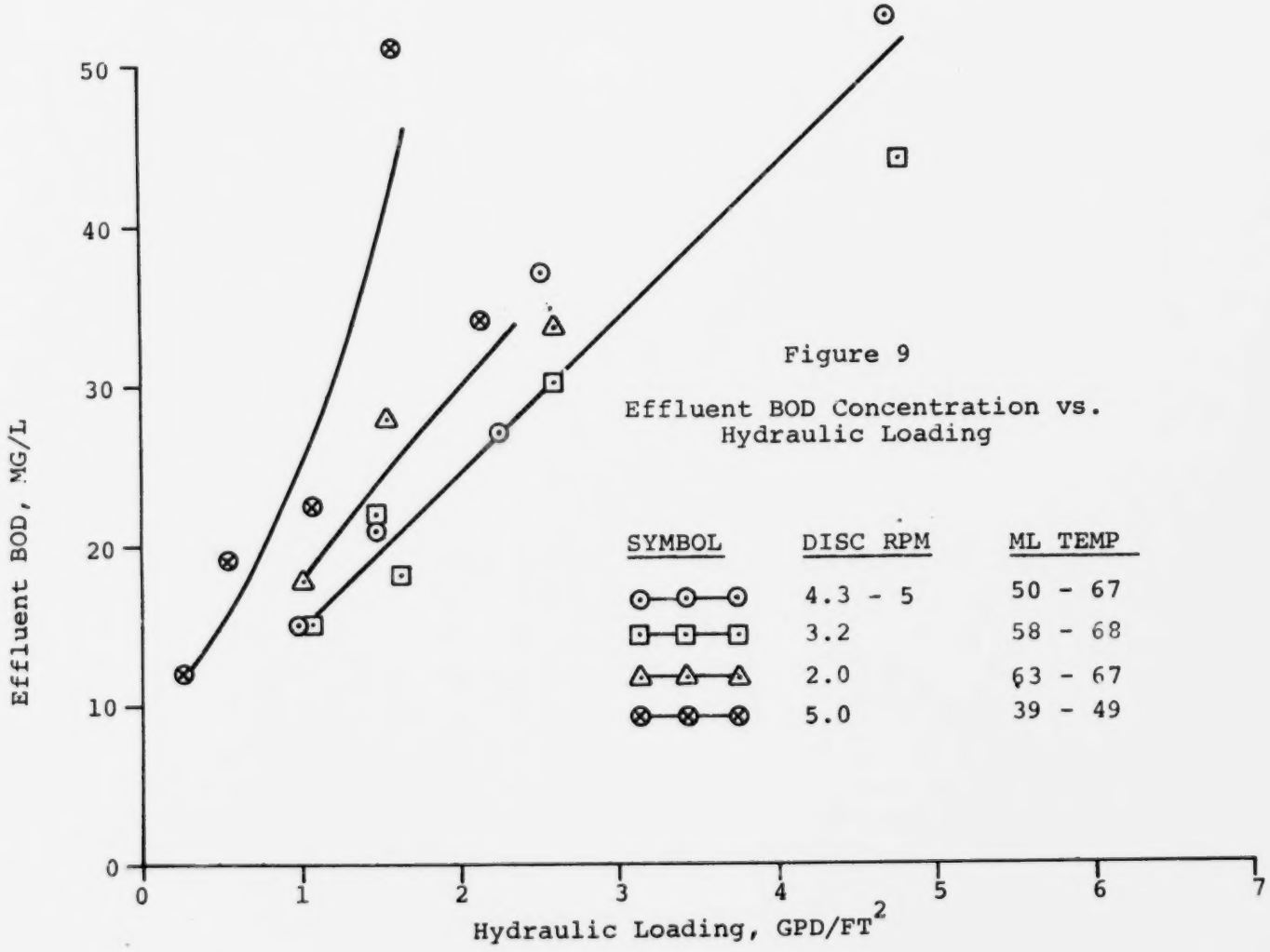


Figure 9

Effluent BOD Concentration vs. Hydraulic Loading

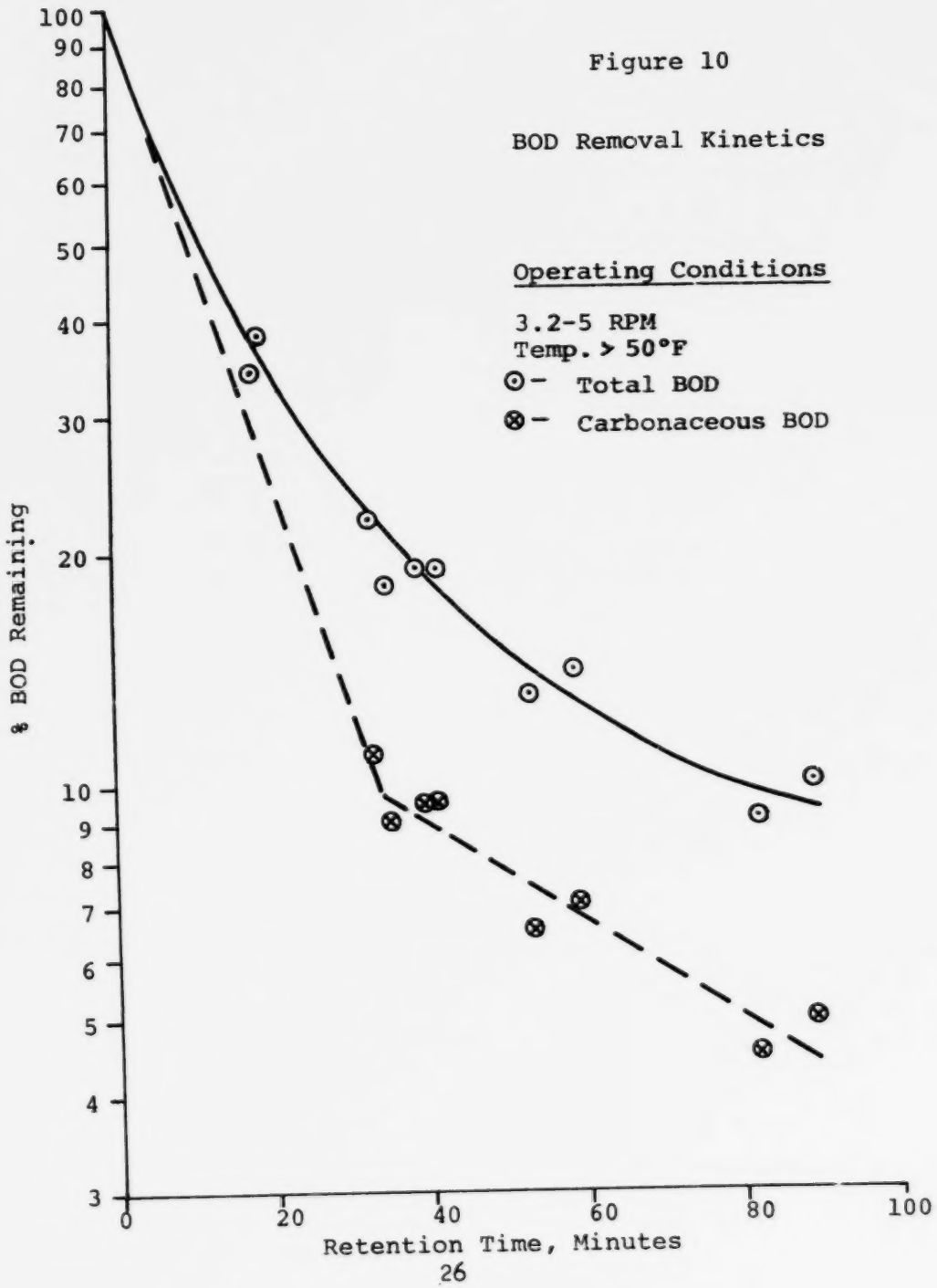

100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
% BOD Remaining
0
20
40
60
80
100
Retention Time, Minutes
Figure 10
BOD Removal Kinetics
Operating Conditions
3.2-5 RPM
Temp. > 50°F
⊙ – Total BOD
⊗ – Carbonaceous BOD

TABLE 4

Determination of Carbonaceous and Nitrogenous BOD

Date	Flow GPH	RPM	Inlet BOD APHA*	Inlet BOD ATU**	Outlet BOD APHA	Outlet BOD ATU
9-1	300	2	168	157	32	16
9-8	300	2	169	165	28	16
9-9	300	2	164	173	33	16
9-9 (6-day)	300	2	182	176	43	17
10-1	503	2	137	---	34	26

*American Public Health Association Method ("Standard Methods")

**As above with 0.5 mg/l allylthiourea in dilution water to suppress nitrification. Reference (1).

Several tests were conducted to determine the proportions of carbonaceous and nitrogenous BOD in the disc system effluent. Addition of allylthiourea to the BOD dilution water to suppress nitrification had no significant effect on the BOD of primary effluent. However, use of allylthiourea in BOD tests of disc system effluent indicates that effluents of less than 35 mg/l BOD consist of about 50% nitrogenous BOD. Carbonaceous BOD removals then corresponding to 80 and 90% "Standard Methods" BOD removal would be 90% and 95%, respectively. A reason for the extent of nitrification occurring in the 5-day BOD test is the presence of nitrifying organisms in the effluent from the final stage of discs.

If all effluents of 80% or better BOD removal are assumed to be 50% nitrogenous (this has been verified in subsequent tests up to 95% BOD removal), the kinetics of carbonaceous BOD removal can also be shown in Figure 10 (dotted line). Carbonaceous BOD removal appears to be first order up to 90% reduction. Above this degree of treatment, carbonaceous BOD removal remains first order, but at a reduced rate because of the predominance of a nitrifying culture on the discs.

Figure 10 is based on test data for wastewater above 50°F. A similar relationship can be developed for wastewater below 50°F, however, only limited data is available.

Suspended Solids Removal

Figures 11 and 12 show suspended solids removal and effluent concentrations as functions of hydraulic loading on the disc sections and clarifier. For a disc section loading of 1.5 to 2.5 gpd/ft^2 and a clarifier overflow rate of 200 to 380 gpd/ft^2, 80% suspended solids reduction was obtained. This yielded an effluent concentration of about 20 mg/l.

A 380-gpd/ft^2 overflow rate in the secondary clarifier corresponds to a retention time of about 70 minutes. This relatively low retention time for a 380 gpd/ft^2 overflow rate is due to the semi-circular shape and 29-inch maximum sidewater depth of the clarifier. A suspended solids removal of 90% and an effluent of 11 mg/l were produced at a disc surface loading of 1.0 gpd/ft^2.

Disc speed did not have as significant an effect on suspended solids removal. While higher percentage removals were obtained at 3.2 and 4.7 RPM than at 2 RPM, lower effluent solids concentrations were produced at 2 RPM. The reason for this is that lower influent solids concentrations existed during the 2 RPM tests.

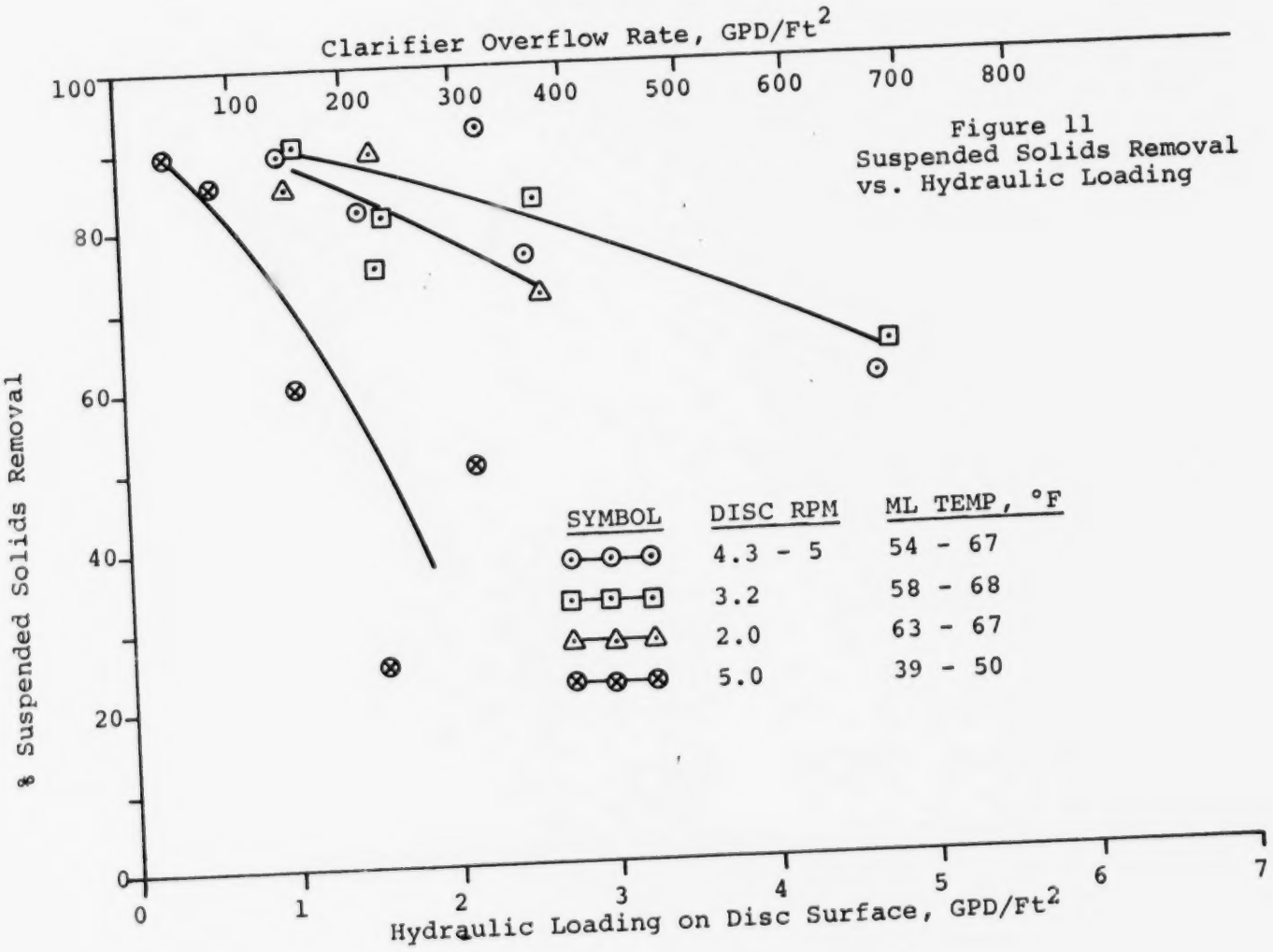
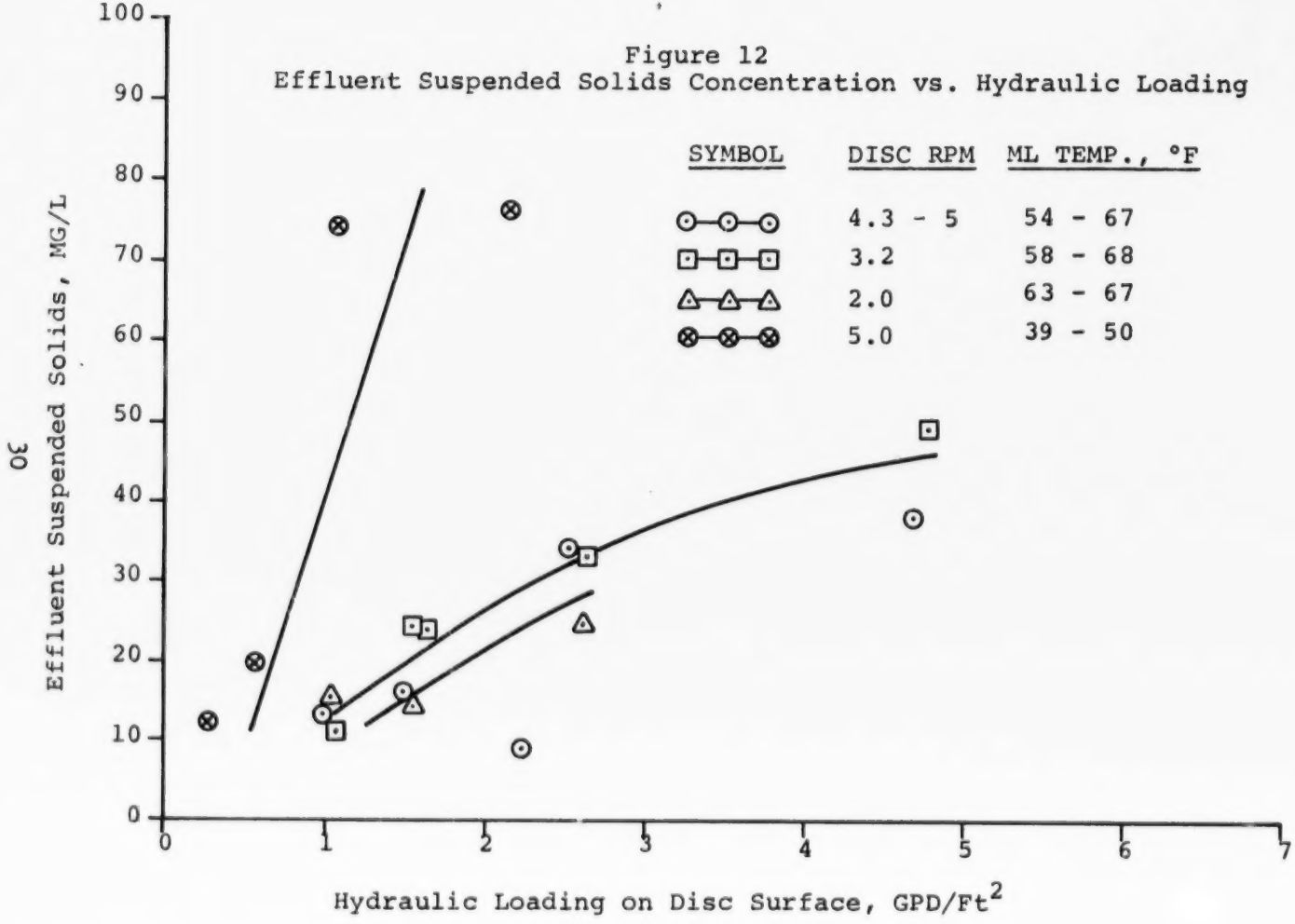


Figure 11
Suspended Solids Removal
vs. Hydraulic Loading

Figure 12
Effluent Suspended Solids Concentration vs. Hydraulic Loading



Wastewater temperature affects suspended solids removal in the same manner as BOD removal; i.e., below 50°F, lower hydraulic loadings are necessary to attain the same removal. The mixing action of the discs appears to flocculate suspended solids very well at all speeds tested and indicates potential for simultaneous biological treatment and flocculation of nutrients with chemical precipitants. The suspended matter remaining in the clarifier effluent is filamentous and flocculent and would appear to filter well in either a sand filter or a microscreen.

COD Removal

COD reduction in Figures 13 and 14 shows relationships of hydraulic loading and disc speed similar to those for BOD and suspended solids removal. One difference is that at wastewater temperatures below 50°F some chemically oxidizable materials are extremely resistant to biochemical oxidation. COD reduction at 2 gpd/ft^2 was not significantly different from that at 0.25 gpd/ft^2.

Ammonia Nitrogen Removal

Figures 15 and 16 show ammonia nitrogen reduction and effluent concentration as a function of hydraulic loading. Separate loading curves are again shown for the different disc speeds and wastewater temperatures. At a hydraulic loading of 1.5 gpd/ft^2, where a 20 mg/l effluent BOD was produced, about 85% removal of ammonia nitrogen was also achieved. An effluent concentration of less than 1.5 mg/l was produced at a loading of 1.0 gpd/ft^2. At still lower loadings during tests on wastewater below 50°F, effluents of less than 0.5 mg/l ammonia nitrogen were produced. Ammonia nitrogen analyses during the low temperature tests were reported to the nearest mg/l; therefore, the reported values of 0.0 mg/l actually represent the range 0.0 to 0.5 mg/l.

The rotating disc method of wastewater treatment is capable of achieving high degrees of ammonia removal in short retention times for two reasons. One is that the system operates as a fixed film biological reactor in which a "captive" population of microorganisms is able to acclimate itself to the particular wastewater it is treating. The other is that by arranging discs in a series of stages, the fixed cultures in successive stages each adapt to the wastewater as it undergoes a progressively increasing degree of treatment. In the case of the two-stage unit tested in this investigation, the first stage developed a culture adapted to metabolizing carbonaceous BOD. With the majority of the carbonaceous matter removed from the wastewater, the second stage then developed a nitrifying culture which metabolized the nitrogenous matter.

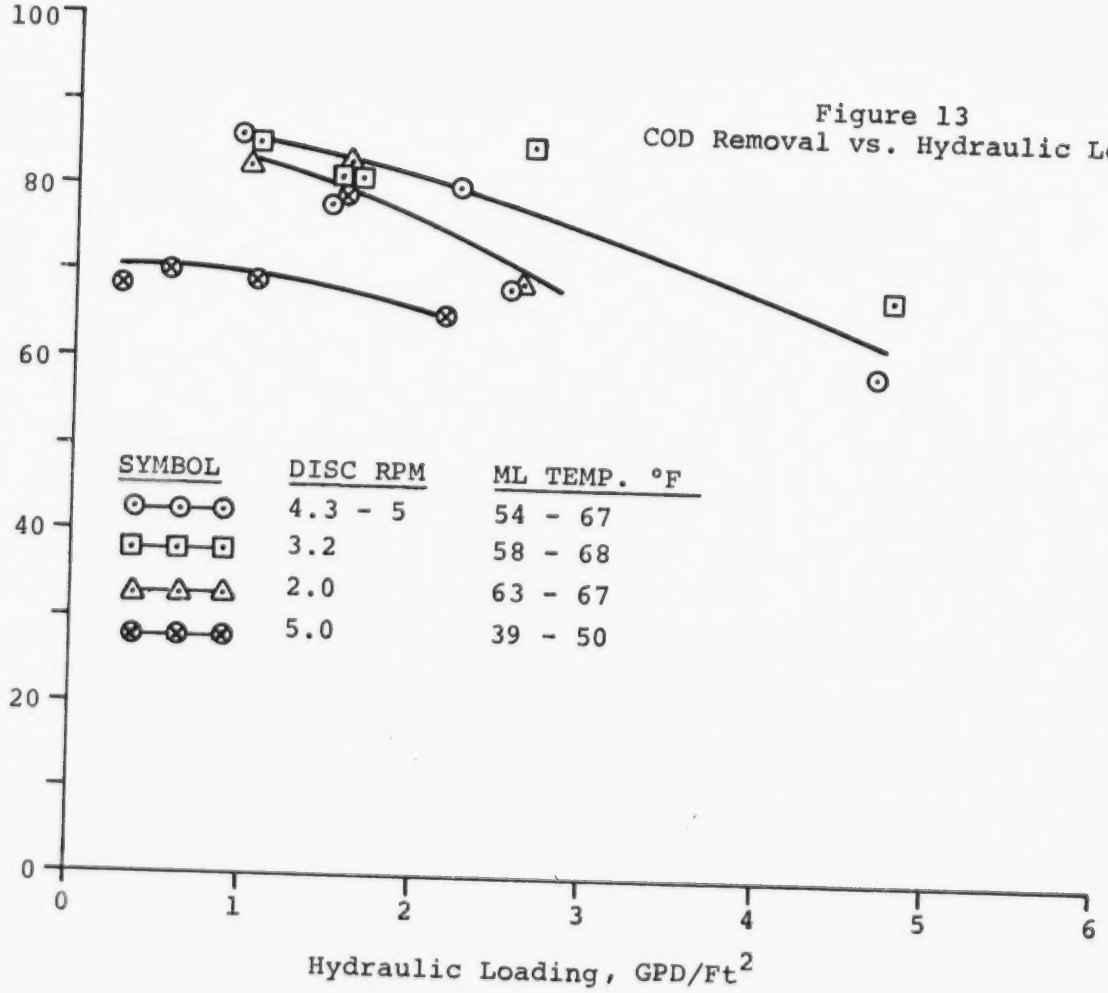


Figure 13
COD Removal vs. Hydraulic Loading

Figure 14
Effluent COD Concentration vs. Hydraulic Loading

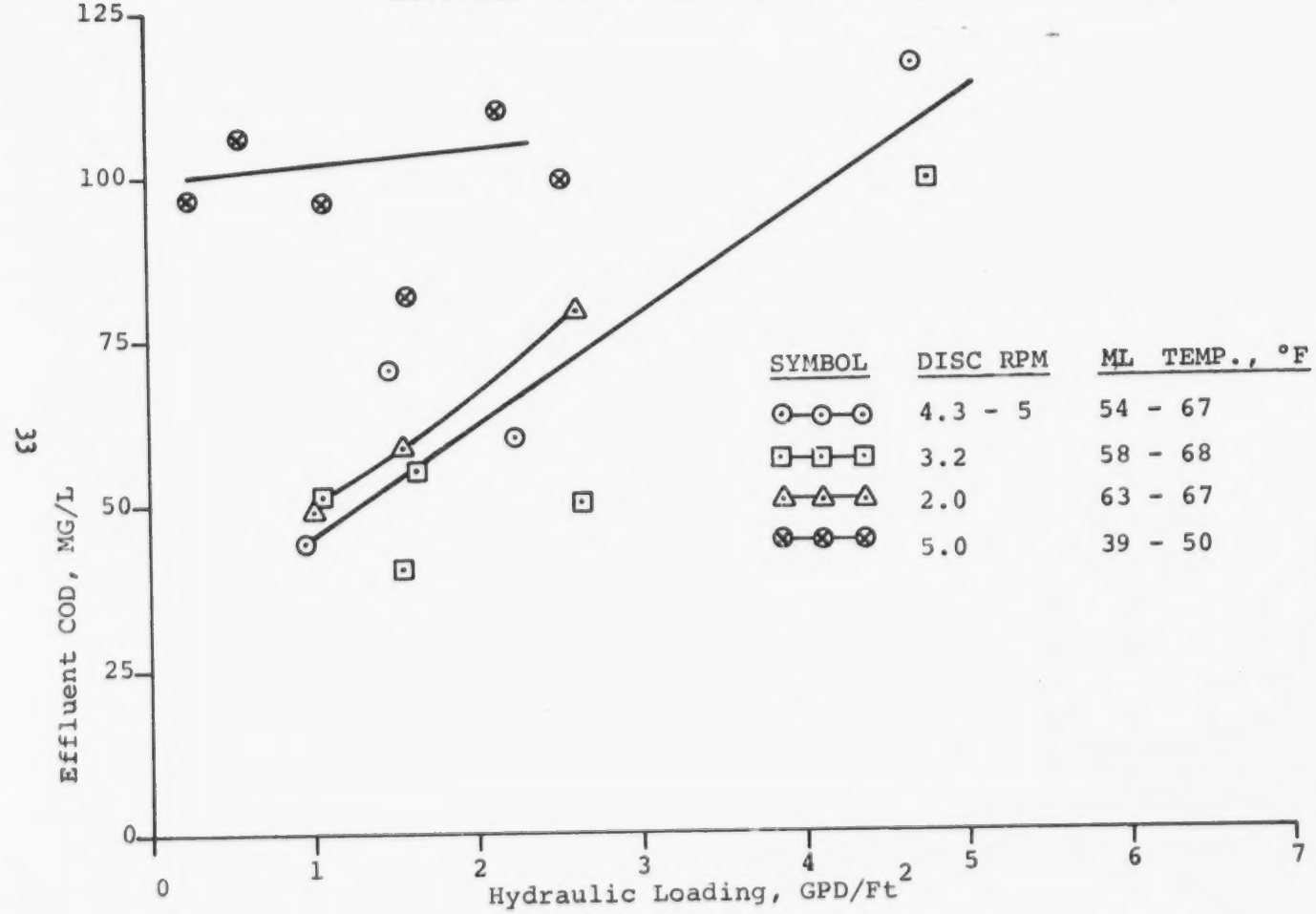


Figure 15
Ammonia Nitrogen Removal vs. Hydraulic Loading

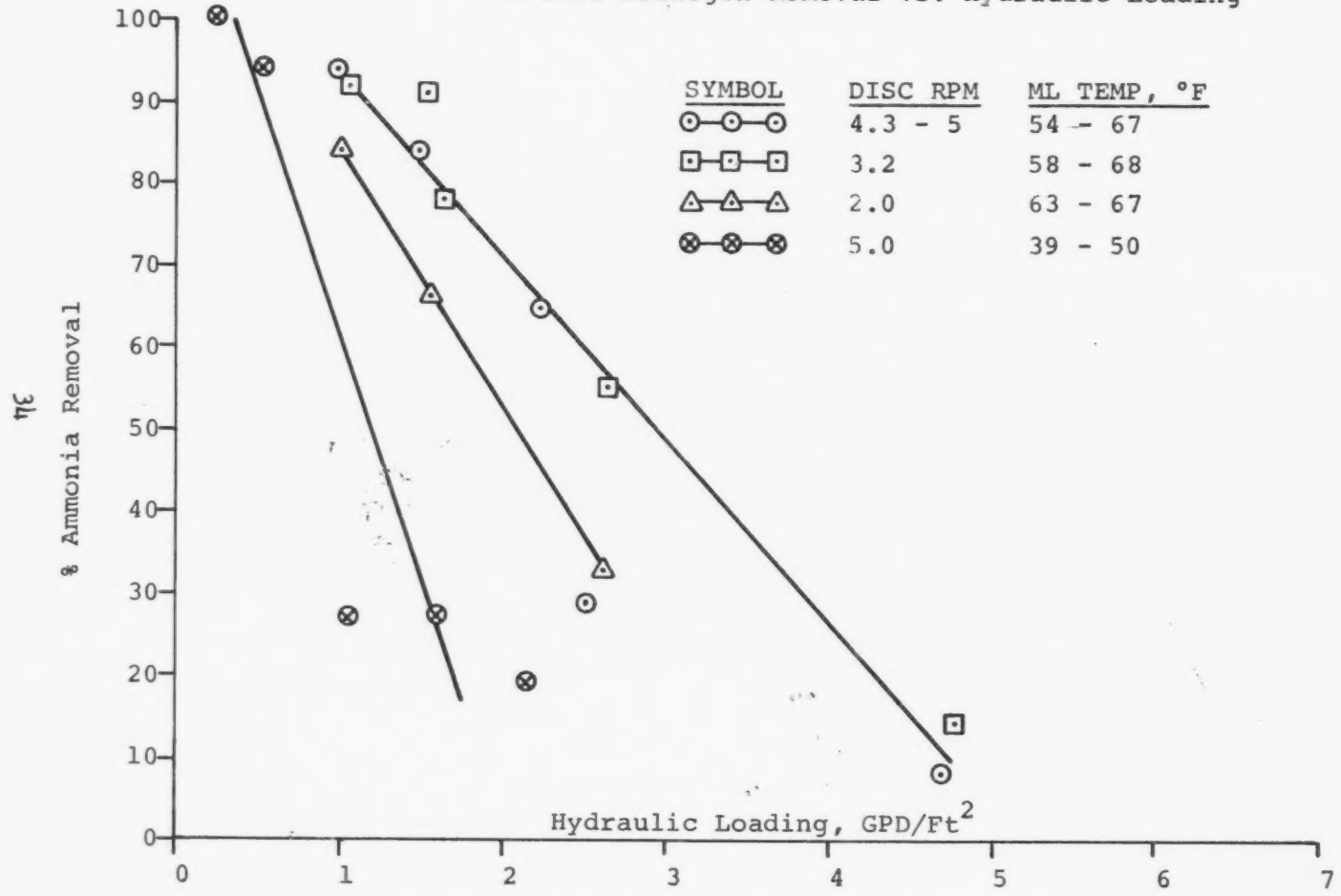
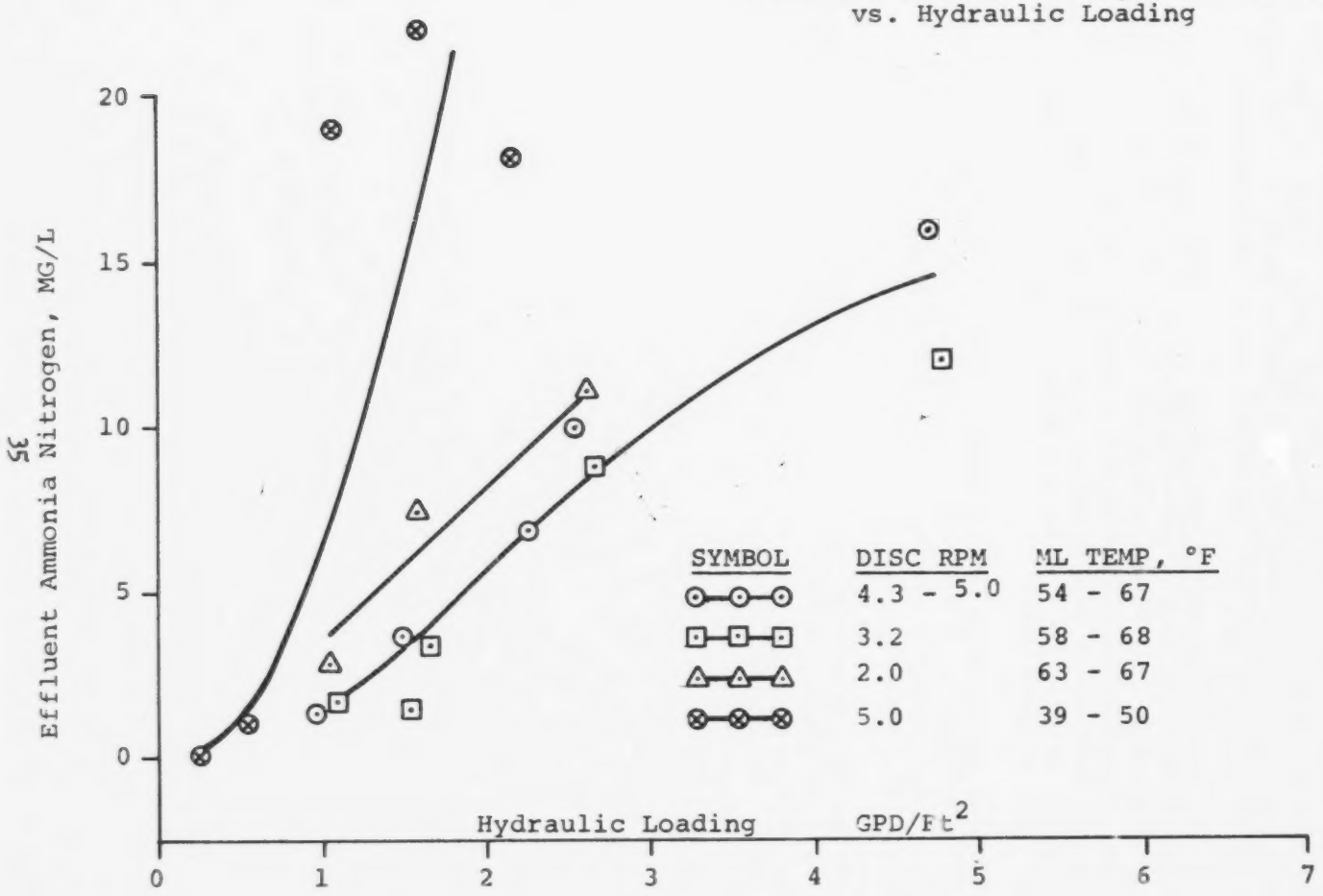


Figure 16
Effluent Ammonia Nitrogen Concentration
vs. Hydraulic Loading



This is shown graphically in Figure 17. Ammonia nitrogen removal did not begin in this two-stage system until the BOD concentration had been reduced to about 60 mg/l. At this point, ammonia removal began and increased rapidly until, at a remaining BOD concentration of about 12 mg/l, ammonia nitrogen removal was virtually complete. This relationship was true for all disc speeds and wastewater temperatures.

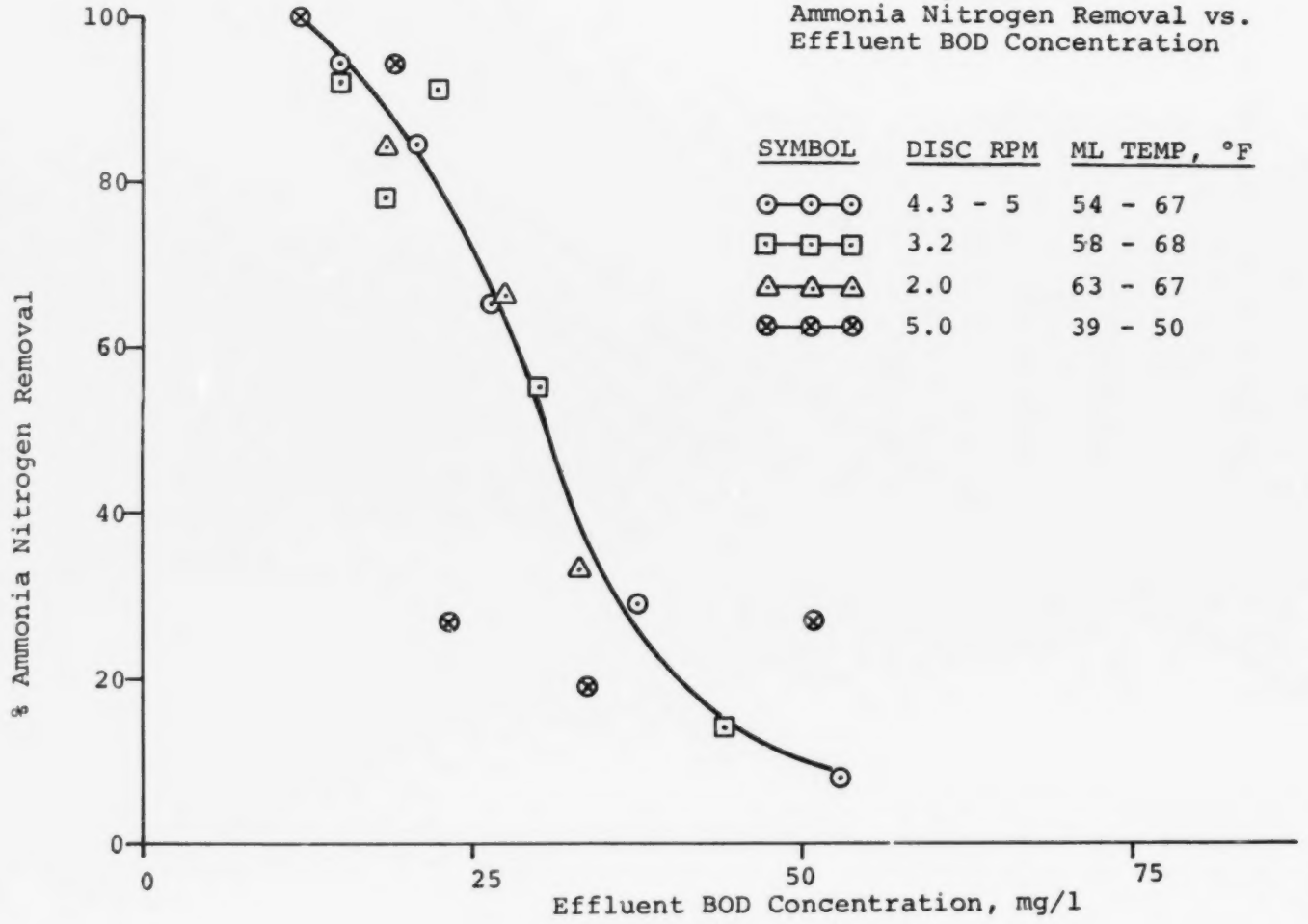
The data on ammonia removal at the higher disc speeds and temperature range is plotted as a function of retention time in Figure 18. The straight-line relationship shows that ammonia removal in the disc system is first order with respect to ammonia concentration at least up to 94% removal and down to 1.3 mg/l effluent ammonia nitrogen. The same type of relationship can be shown for low wastewater temperature, however, only limited data is available.

Because both carbonaceous BOD and ammonia nitrogen removal are approximately first order with respect to carbonaceous BOD and ammonia nitrogen concentration, hydraulic loading is the primary design criterion for the rotating disc process.

Most of the ammonia nitrogen removal consists of oxidation to nitrate and nitrite nitrogen. Figure 19 shows the ration of nitrate and nitrite nitrogen produced per unit ammonia nitrogen removed for the various disc speeds and wastewater temperatures tested. At the higher hydraulic loadings, a greater proportion of the ammonia removal is attributable to cell synthesis. At the lower loadings, where nitrifying organisms predominate, a greater proportion of ammonia removal is conversion to nitrate and nitrite. This data is generalized for all disc speeds and temperatures in Figure 20 as a function of degree of ammonia removal. It shows that a maximum of about 80% conversion to nitrate and nitrite is obtained at the point of virtually complete nitrification. The other 20% is accounted for by cell synthesis, ammonia stripping by the discs, and possibly some denitrification.

All tests in this investigation were conducted at normal municipal wastewater pH. The pH of wastewater is reported to have a significant effect on the rate of biological nitrification.[2] It would be a worthwhile investigation to attempt to accelerate nitrification rate by chemical addition for pH adjustment in later stages of a multi-stage disc system. This would be especially important for reducing surface area requirements when wastewater temperatures were below 50°F.

Figure 17
Ammonia Nitrogen Removal vs.
Effluent BOD Concentration



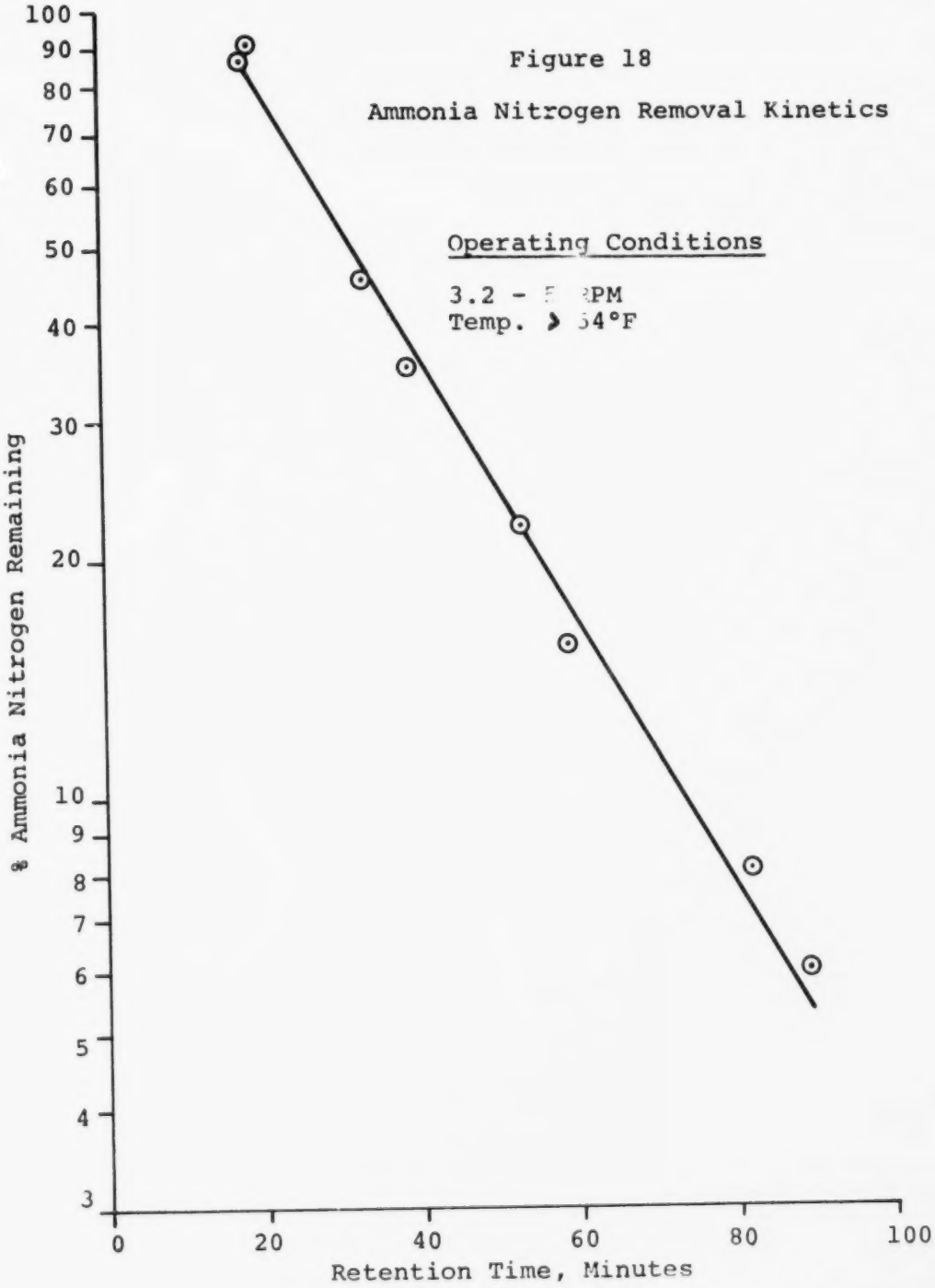


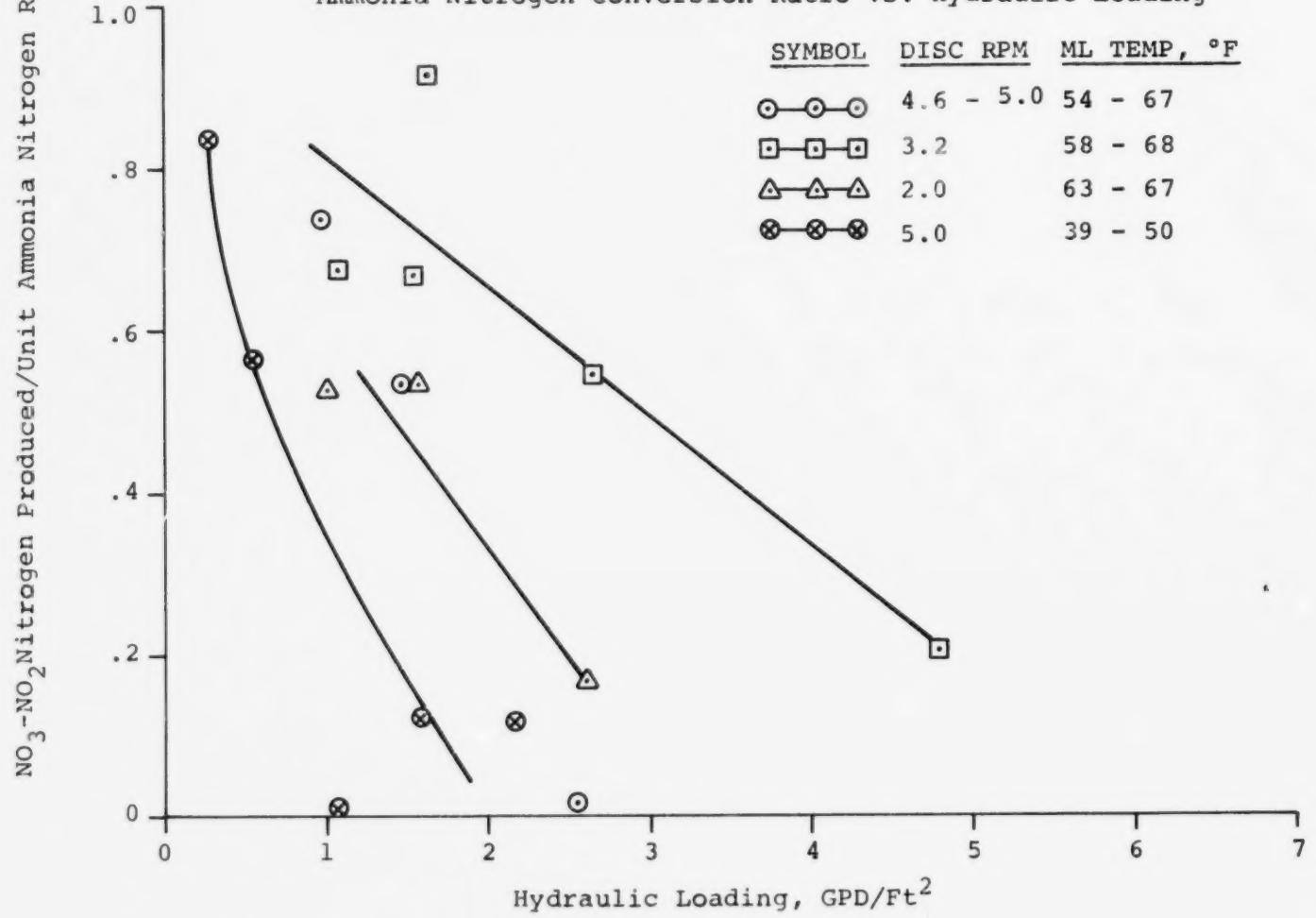
Figure 18

Ammonia Nitrogen Removal Kinetics

Operating Conditions

3.2 - [illegible]PM
Temp. > 54°F

Figure 19
Ammonia Nitrogen Conversion Ratio vs. Hydraulic Loading



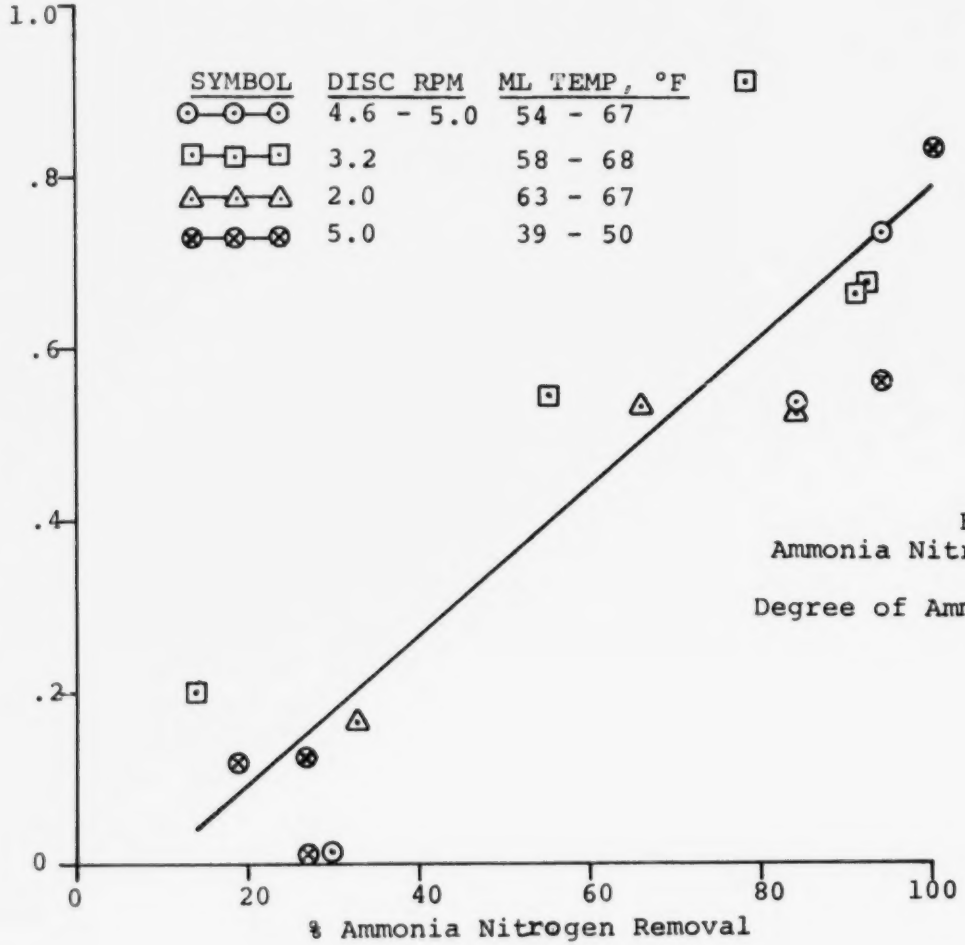


Figure 20
Ammonia Nitrogen Conversion Ratio
vs.
Degree of Ammonia Nitrogen Removal

Kjeldahl Nitrogen Removal

Kjeldahl nitrogen removal and effluent concentrations shown in Figures 21 and 22 follow patterns very similar to ammonia nitrogen removal. At a given hydraulic loading, removal percentages are somewhat lower and effluent concentrations somewhat higher than for ammonia nitrogen. The difference is attributable to residual soluble and colloidal organic nitrogen and organic nitrogen in the suspended matter remaining in the clarifier effluent.

Total Nitrogen Removal

Total nitrogen removal did not exceed 60%, and effluent concentrations did not go below 10 mg/l under any of the test conditions.

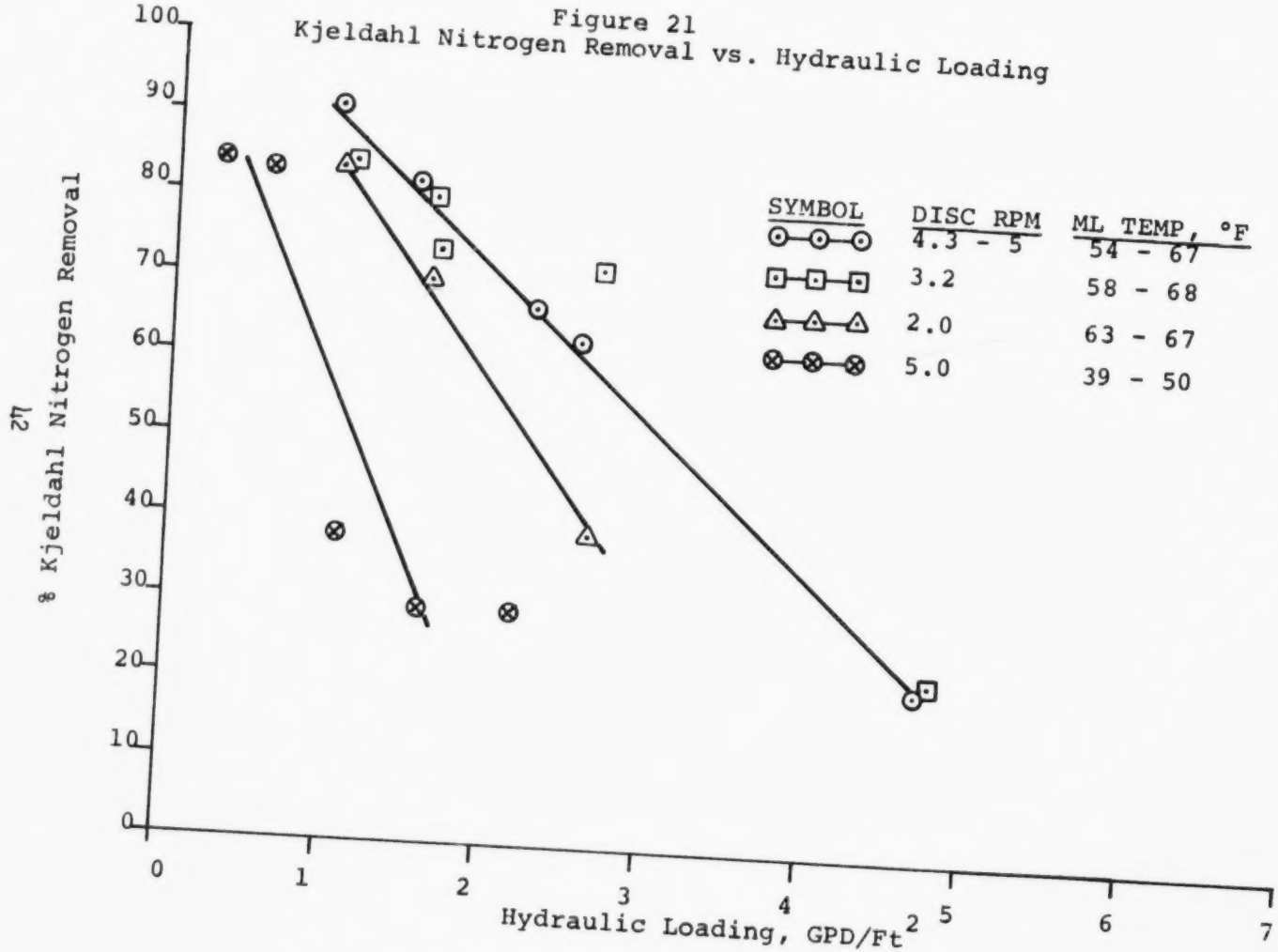
Total nitrogen removal was accomplished primarily through cell synthesis and settling, although ammonia stripping and possibly some denitrification are likely to have occurred. The removal limits of 60% and 10 mg/l in the effluent are imposed by formation of nitrate and nitrite nitrogen from ammonia by nitrifying organisms.

Some correlation exists among hydraulic loading, disc speed, and wastewater temperature as they affect nitrogen removal and effluent nitrogen concentrations in Figures 23 and 24. The greater removal of nitrogen at the higher disc speeds and wastewater temperatures reflects greater biological activity and incorporation of nitrogen into cell synthesis under these conditions. Ammonia stripping would also be more significant at the higher temperatures and disc speeds.

Phosphorus Removal

Total phosphorus removals in the data summary in the Appendix vary generally from 10 to 30% with an overall average of about 20%. No apparent correlation could be found between phosphorus removal and any of the primary operating parameters of the system. On the average, 0.02 units of phosphorus were removed per unit BOD removal. This is higher than the normal phosphorus requirement in biological wastewater treatment of 0.01 unit per unit of BOD present. The difference is likely due to flocculation and settling of organically bound phosphorus, because orthophosphorus concentration generally increased rather than decreased through the disc unit.

Figure 21
Kjeldahl Nitrogen Removal vs. Hydraulic Loading



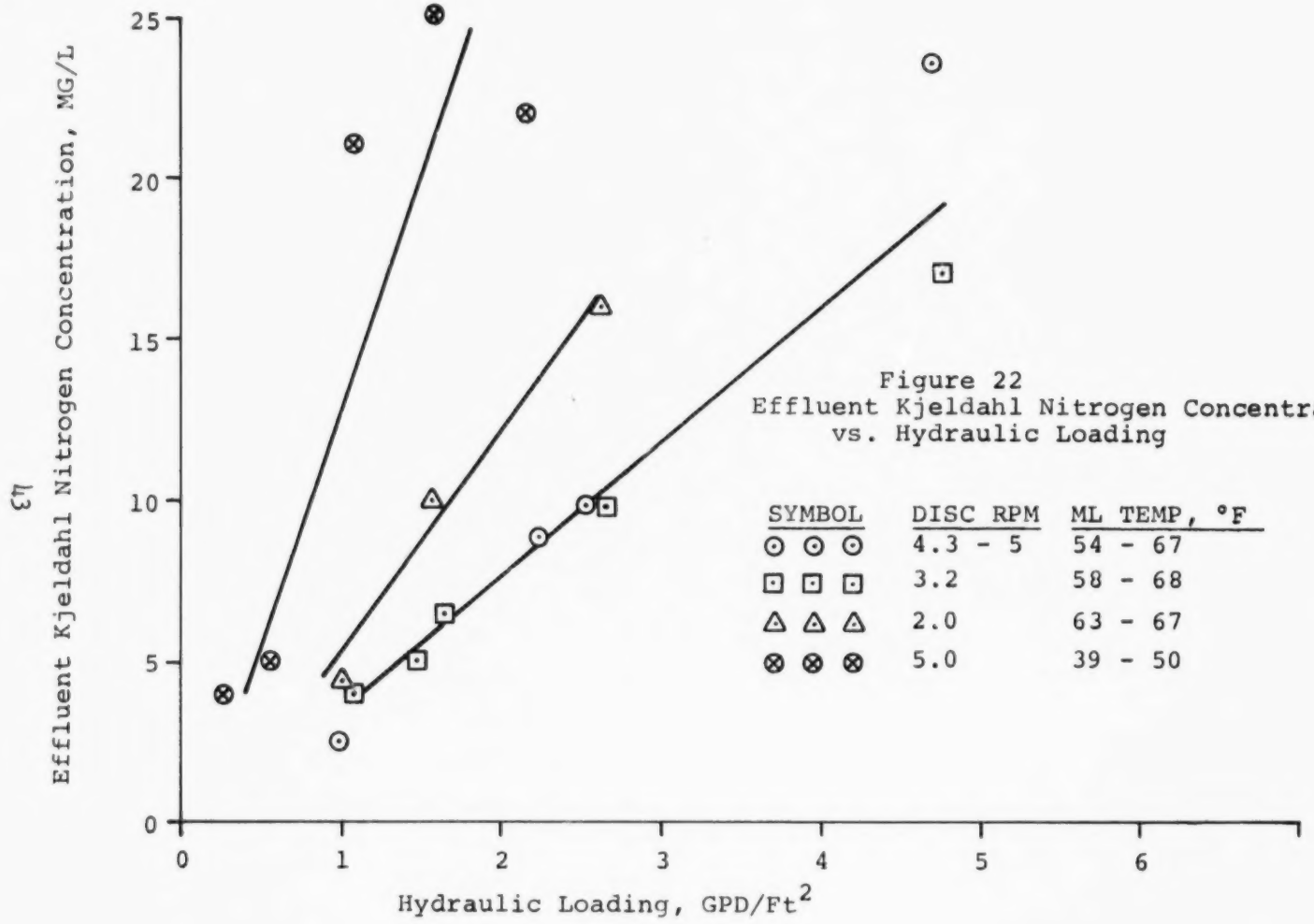


Figure 22
Effluent Kjeldahl Nitrogen Concentration
vs. Hydraulic Loading

SYMBOL	DISC RPM	ML TEMP, °F
⊙ ⊙ ⊙	4.3 - 5	54 - 67
⊡ ⊡ ⊡	3.2	58 - 68
△ △ △	2.0	63 - 67
⊗ ⊗ ⊗	5.0	39 - 50

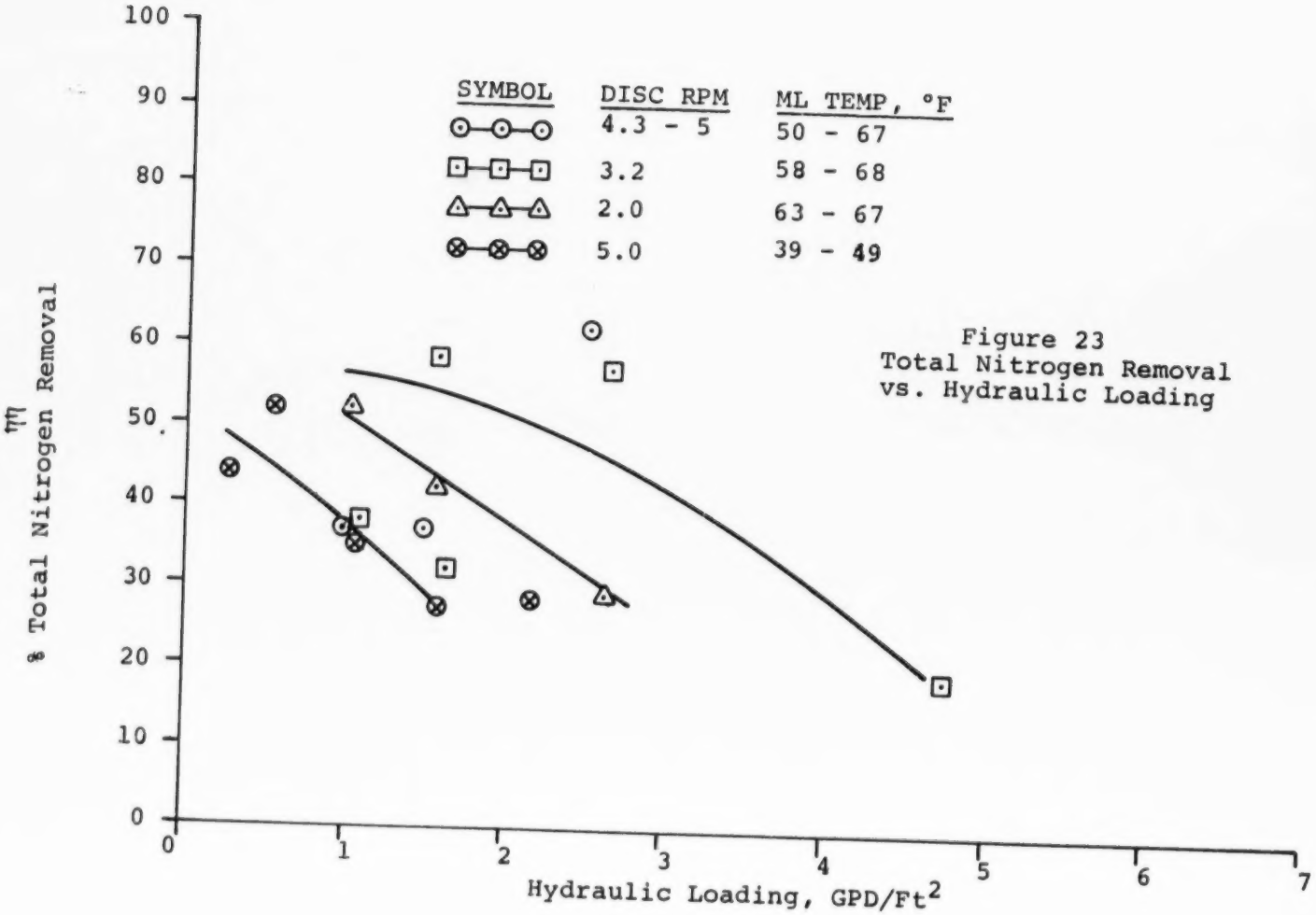
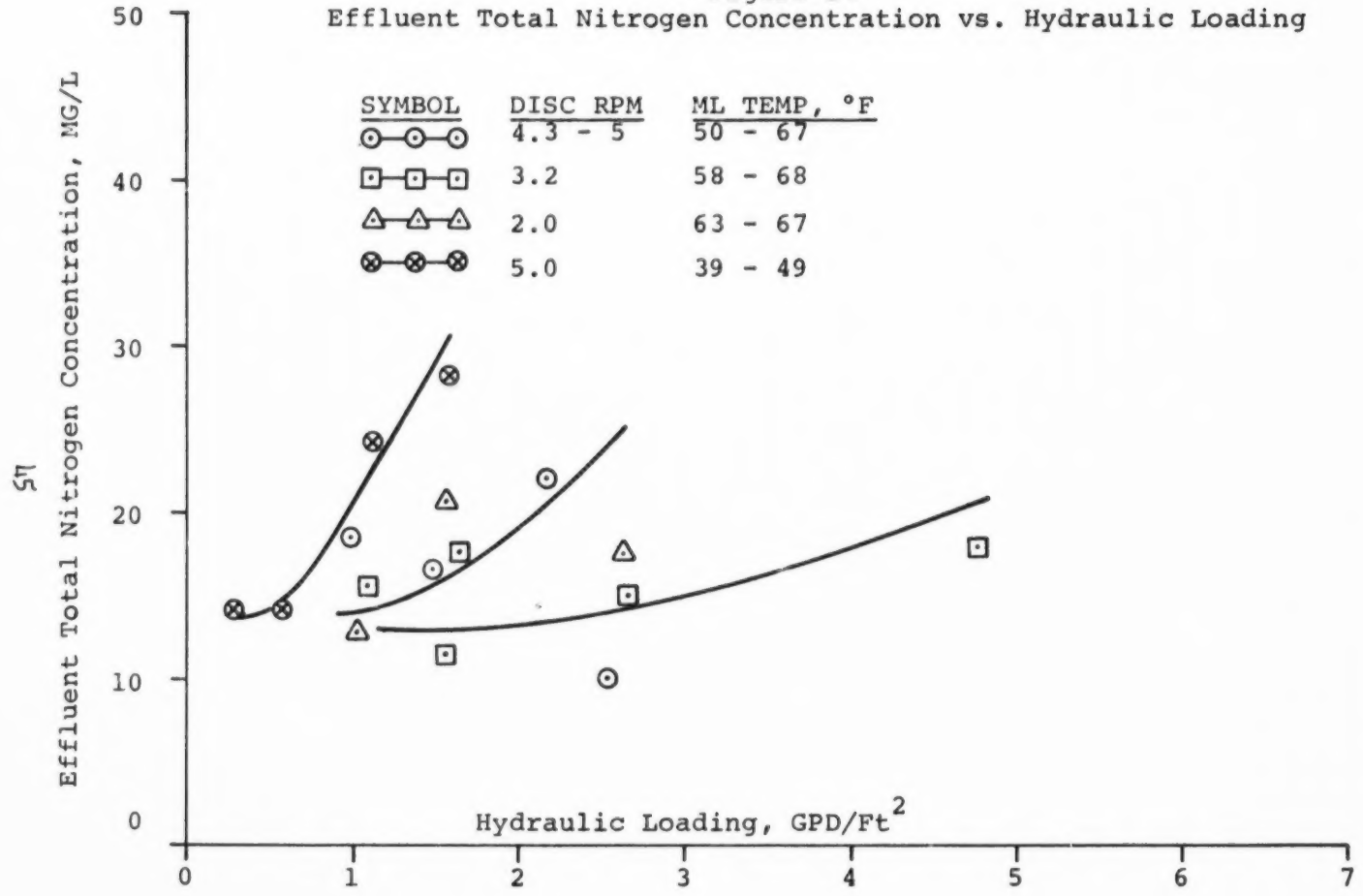


Figure 23
Total Nitrogen Removal
vs. Hydraulic Loading

Figure 24
Effluent Total Nitrogen Concentration vs. Hydraulic Loading



Power Consumption

The expanded polystyrene used for disc fabrication is very buoyant. In operation, the buoyancy of the discs offsets the weight of the biomass and the disc support structure, so that power to overcome friction between the biomass and the wastewater is the only power required for rotation. Figure 25 shows power measurements made on the package plant as a function of disc speed.

Power requirements were determined by mounting a hydraulic motor in a cradle and measuring reaction torque at various speeds. (See Figure 5.) Very little power is required to operate the package plant; however, power requirements do increase rapidly with disc speed. Previous correlations have shown package plant performance at 3.2 and 4.3-5 rpm to be superior to that at 2.0 rpm. In spite of this, Figure 26 shows that a speed of 2.0 rpm makes more efficient use of power for all the treatment levels obtained. However, considering that much less surface area is required for a given degree of treatment, the increased power consumption at higher disc speeds seems justified.

At the disc speed of 3.2 rpm, 5.2 lb. BOD are removed per hp—hr for 87% BOD reduction through the discs and an effluent of 18 mg/l BOD. This power consumption converts to 8 HP per MGD plant capacity or 0.2 hp-hr per 1,000 gal. of wastewater treated. This power requirement applies to consumption by the discs and bearings only and does not include motor or drive inefficiencies.

Power consumption by the rotating disc process would be optimized further than what was accomplished during this investigation. In determining the optimum disc velocity, it was necessary by nature of the construction of the test unit to operate both stages of discs at the same rotational velocity. In a multi-stage disc system, it seems likely that each successive stage of discs would have an optimum velocity which would decrease as the degree of treatment increased.

Sludge Production

Sludge production by the test unit was calculated by subtracting the suspended solids concentration in the clarifier effluent from the suspended solids concentration in the second stage of discs. This difference represents the amount of sludge solids which settled in the clarifier. Dividing this by the decrease in BOD concentration through the test unit yields sludge production as sludge produced per unit BOD removed.

Figure 25

Power Requirement vs. Disc Speed

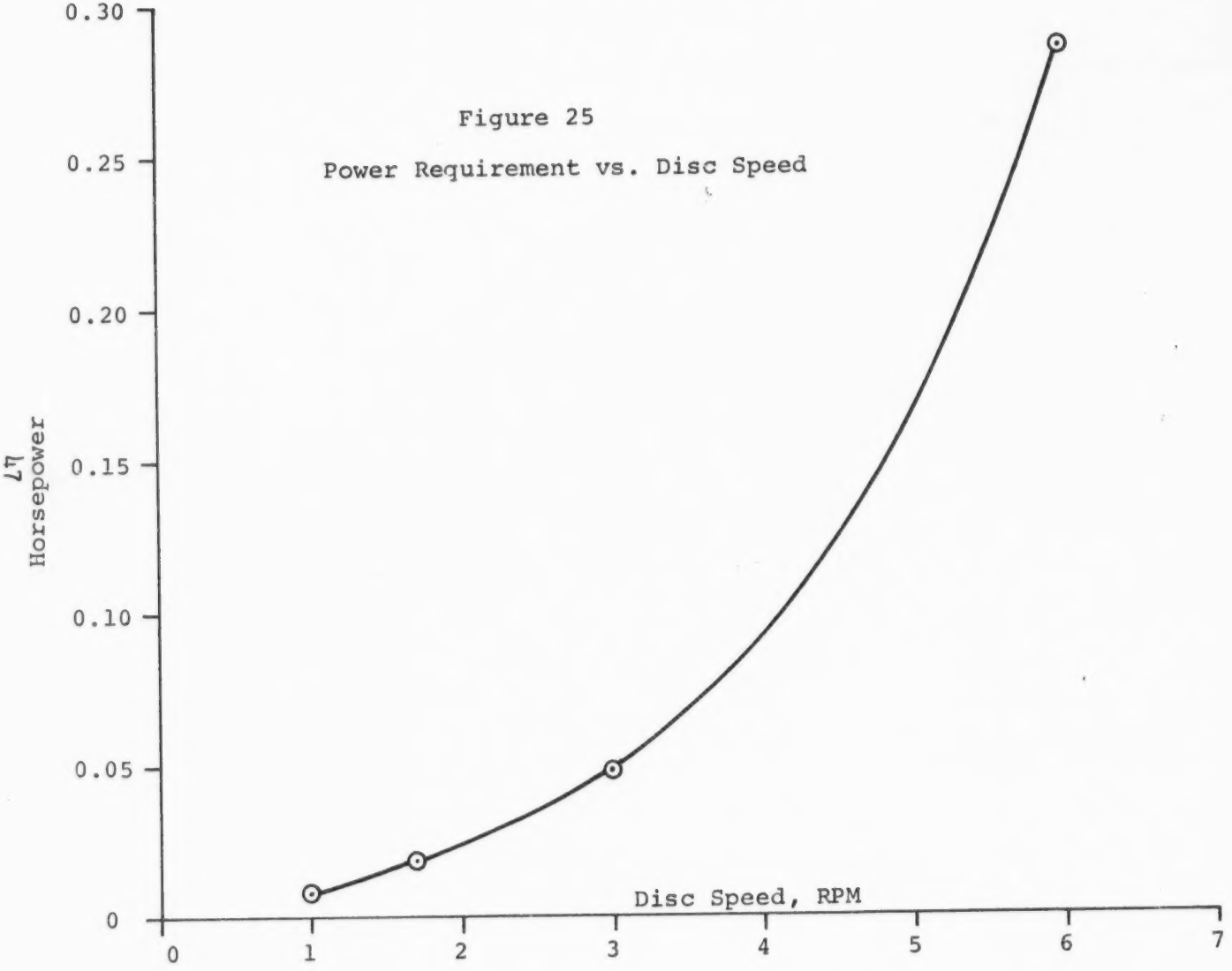
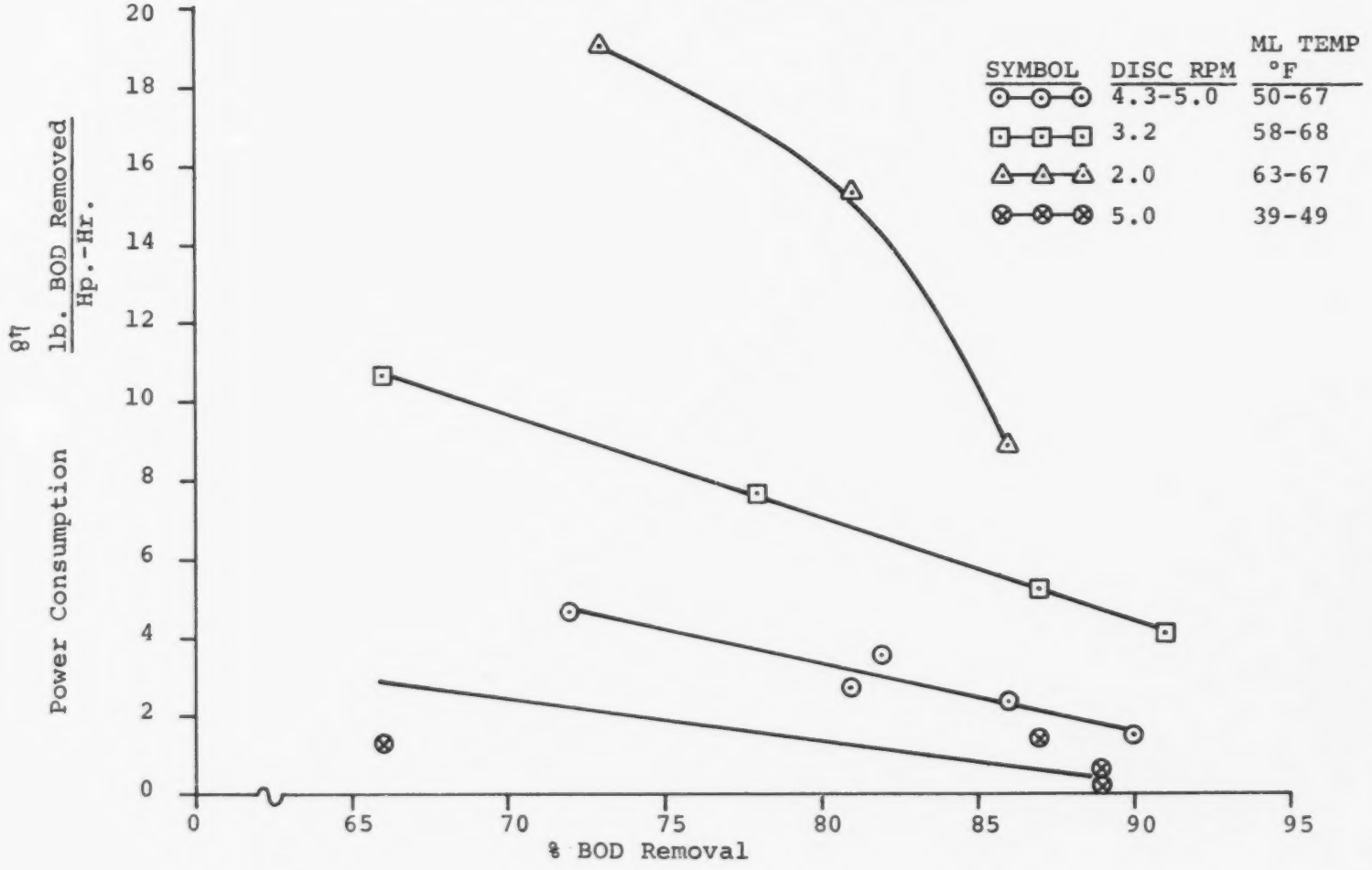


Figure 26
Power Consumption vs. Degree of Treatment



Sludge production as a function of degree of treatment is presented in Figure 27. The data is scattered, which may indicate difficulty in obtaining accurate mixed liquor samples. Sludge production appears to be much higher when treating wastewater below 50°F. No consistent effect of disc speed can be noted. Sludge production does appear to decrease as the degree of treatment increases as would be expected. At a BOD removal of 86%, which would correspond to an effluent of 20 mg/l BOD, 0.5 to 0.6 lb. sludge were produced per lb. BOD removed. Sludge solids were 80% volatile under all test conditions.

Sludge production will be examined more closely during testing of the demonstration plant at Pewaukee.

Mixed Liquor Characteristics

The parameters of pH, dissolved oxygen concentration, and suspended solids for the mixed liquor of the two stages of discs are summarized in Table 5.

For wastewater above 50°F, suspended matter decreased from Stage 1 to Stage 2 to a concentration generally under 100 mg/l. Mixed liquor solids are filamentous and very dense and appear to settle and thicken well. They also would appear to be readily removed by mechanical means, such as sand filtration or microscreening. In treatment applications where an alternative to a settling tank for secondary clarification is desirable, mechanical separation may be possible when using the rotating disc system for secondary treatment. This is an area which warrants investigation.

For wastewater temperatures below 50°F, suspended matter generally increased from Stage 1 to Stage 2 to concentrations ranging from 130 to 250 mg/l. This accounts for the higher calculated sludge production rate at lower wastewater temperatures.

Effluent pH varied from 7.2 to 8.0 at wastewater temperatures above 50°F. Below 50°F, pH varied from 7.6 to 8.5 Higher pH values at the colder temperatures may have contributed to the high degrees of nitrification obtained in spite of the low temperatures. A pH of 8.5 is near the optimum reported for biological nitrification. (2)

Disc speed may also have had an effect on pH. At 2 RPM, pH ranged from 7.2 to 7.6. At 3.2 to 4.7 RPM, pH ranged from 7.6 to 8.0. More effective stripping of dissolved CO_2 may be the reason for the higher pH values. The higher pH values could have contributed to better nitrification at the higher disc speeds.

Figure 27
Sludge Production vs. Degree of Treatment

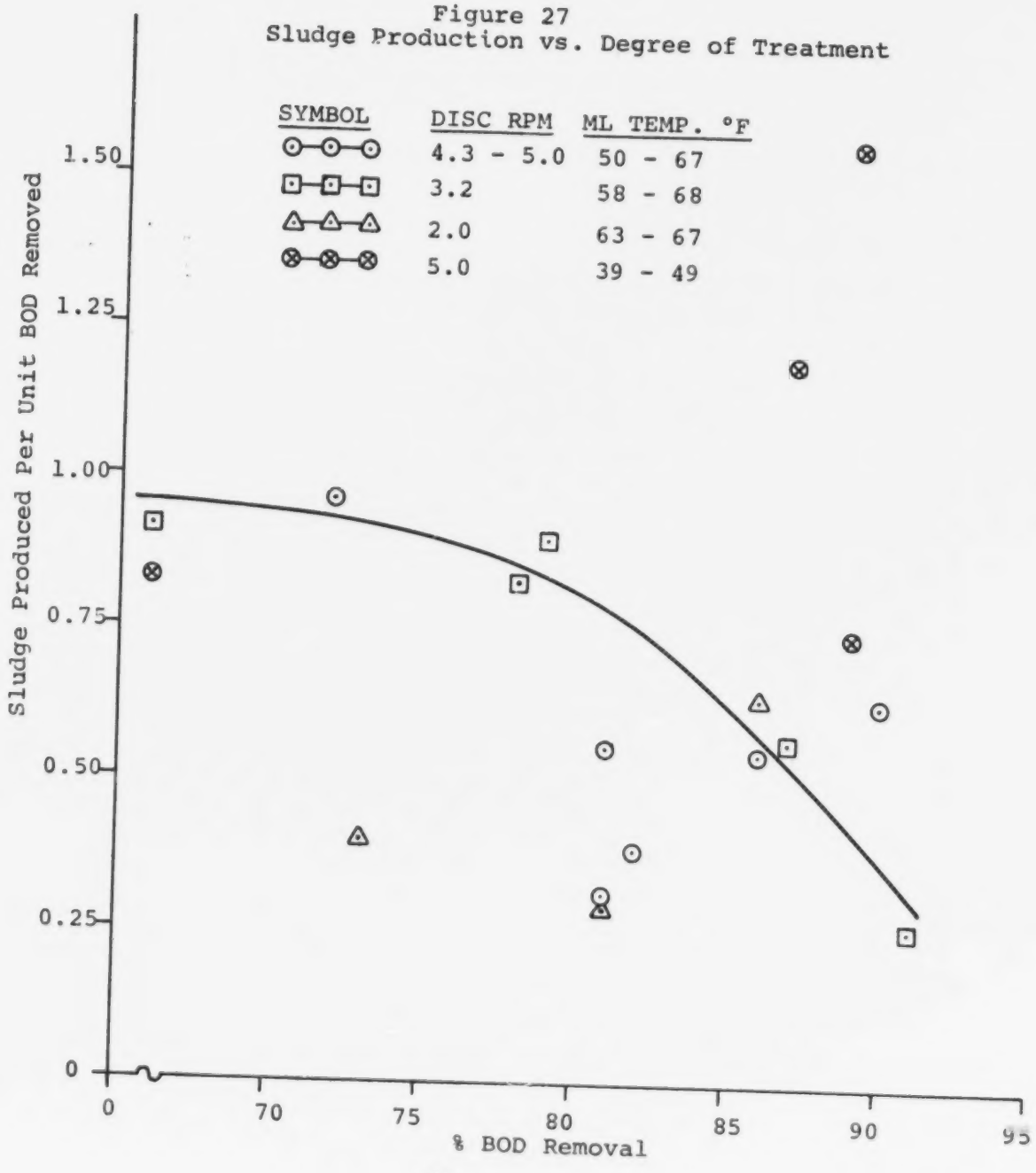


TABLE 5

MIXED LIQUOR CHARACTERISTICS

TEST PERIOD AVERAGES

Test Period Dates	Disc Stage	Susp. Solids (mg/l)	RPM	D.O.	Temp. °F	pH
11/13-12/19	1	275	5		54	-
	2	99	5		-	7.3
12/23-1/19	1	228	5		50	-
	2	122	5		-	7.6
1/20-2/9	1	146	5		49	-
	2	200	5		-	8.0
2/10-2/13	1	202	5		42	-
	2	256	5		-	7.6
2/25-3/2	1	250	5		39	-
	2	131	5		-	8.5
3/3-3/9	1	154	5		45	-
	2	167	5		-	8.5
4/1-5/15	1	138	3.2		-	-
	2	97	3.2		-	-
5/20-6/5	1	268	3.2		58	-
	2	123	3.2		-	8.2
6/10-6/19	1	238	3.2		61	-
	2	126	3.2		-	8.0
6/22-7/17	1	132	3.2		66	-
	2	91	3.2		-	7.8
7/22-8/7	1	171	3.2		68	-
	2	49	3.2		-	7.9
8/12-8/17	1	128	4.3	1.7	67	-
	2	72	4.3	3.6	-	8.0
8/18-8/21	1	196	4.6	3.3	66	-
	2	89	4.6	3.7	-	7.7
8/24-8/29	1	167	4.7	3.8	67	-
	2	96	4.7	5.1	-	7.6
8/31-9/11	1	170	2.0	1.0	66	-
	2	50	2.0	2.6	-	7.6
9/14-9/25	1	139	2.0	2.0	64	-
	2	84	2.0	3.8	-	7.2
9/28-10/3	1	104	2.0	2.6	63	-
	2	60	2.0	4.0	-	-
10/7-10/23	1	88	4.7	3.1	63	-
	2	121	4.7	4.0	-	-

Samples of mixed liquor taken for laboratory analyses were 24-hour composites. Because the mixed liquor solids and supernatant were of necessity kept in the same container for the 24-hour sampling period, the laboratory analyses for solids, nitrogen, and phosphorus may not be truly indicative of conditions which existed in the mixed liquors.

Dissolved oxygen concentration in Stage 1 varied from 1.0 to 3.8 mg/l, depending upon hydraulic loading and disc speed. Stage 2 dissolved oxygen concentrations were 1 to 2 mg/l higher than Stage 1. Less than 1.0 mg/l of dissolved oxygen was consumed in the secondary clarifier, so that effluent dissolved oxygen concentrations were always several milligrams per liter. At wastewater temperatures below 50°F, dissolved oxygen concentrations in the effluent ranged between 7 and 10 mg/l, which indicates that mixed liquor concentrations were also quite high.

Sludge Recycle

Several brief tests were conducted to determine if recycling settled secondary sludge to the first stage of discs would enhance treatment of the wastewater. Sludge removed from the clarifier by the scoop system was collected in a drum and pumped into the first stage of discs at rates of 1% and 2% of the wastewater flow.

Table 6 is a summary of operating data during sludge recycle and during comparable periods without sludge recycle. The amounts of sludge recycled apparently had little effect on the concentration of mixed liquor solids. As a consequence, there was no distinct effect on treatment efficiency. At the 1% recycle rate, BOD and COD removals were lower than without sludge recycle. Suspended solids removal increased in one case and remained the same in the other. Ammonia nitrogen removal increased in one case and decreased in the other. At the 2% recycle rate, BOD and COD removals increased; however, mixed liquor solids concentrations were actually lower with sludge recycle than without.

The proportion of volatile to fixed solids in the mixed liquor was unchanged by recycling sludge. The sludge recycle rates tested had no apparent effect on any system parameters. To determine the effect of sludge recycle, further tests at much higher recycle rates will be necessary. This is being planned during testing of the demonstration plant at Pewaukee.

TABLE 6

Effect of Sludge Recycle on Treatment Efficiency

Test Period	Hydraulic Loading GPD/ft^2	ML Temp. oF	Sludge Recycle Rate % of Total Flow	Stage	Mixed Liquor Susp. Solids		% Removal			
					Total	Volatile	BOD	COD	SS	NH_3-N
					(mg/l)					
2/10-2/13	1.06	42	0	1	202	160	87	69	60	27
				2	256	189				
2/16-2/20	1.06	42	1	1	230	192	84	66	81	25
				2	249	200				
2/25-3/2	0.55	39	0	1	250	220	89	70	85	94
				2	131	125				
2/23-2/24	0.47	44	1	1	88	83	85	60	85~100	
				2	140	133				
3/3-3/9	0.26	45	0	1	154	136	89	68	89~100	
				2	167	143				
3/10-3/13	0.26	40	2	1	113	90	93	88	90~100	
				2	75	61				

Maintenance

The rotating disc process is inherently simple. There are just a few simple mechanical parts, and there is no need to recycle sludge or effluent. The only regular maintenance required is to grease bearings and check oil levels in drive system components. As long as disc rotation is maintained, the process will operate satisfactorily. Low maintenance makes the rotating disc process very attractive for package plant installations and especially for wastewater treatment in remote areas.

SECTION VIII

COMPARISON TO PREVIOUS ROTATING DISC PROCESS EXPERIENCE

Previous testing of a rotating disc system on municipal wastewater in the U.S. was conducted at the Jones Island Sewage Treatment Plant of the Milwaukee Metropolitan Sewerage Commission. These tests were conducted under Environmental Protection Agency Contract 14-12-24.(3) Table 7 is a comparison of the Jones Island test unit and operating conditions with those for this investigation. Figure 28 compares the design hydraulic loading curve determined from Figure 8 at higher temperatures and disc speeds with the results of the Jones Island tests. The Jones Island test unit yielded equal or better percentage BOD removals at all hydraulic loadings tested, even though the organic loading was considerably higher. This demonstrates that the rotating disc process is first order with respect to BOD concentration from 147 mg/l at least up to 426/mg/l for municipal wastewater.

A factor contributing to the better performance by the Jones Island test unit was the larger number of stages of discs. Residence time distribution tests on the 10-shaft unit revealed that 4-6 equivalent, completely mixed stages in series were obtained at the wastewater flows tested. A separate stage of treatment for each shaft was not obtained because of the high degree of backmixing between adjacent shafts. Similar tests on the Pewaukee test unit indicated that each stage was thoroughly mixed, and it therefore operated as a two-stage reactor.

TABLE 7

Comparison with Previous Test Unit

		Jones Island	Pewaukee
a.	Disc Diameter, Ft.	1	5.74
b.	Disc Velocity, RPM	15-30	2-5
c.	Disc Shafts or Stages, No.	10	2
d.	Effective Disc Area, Ft^2	500	4,600
e.	Disc Spacing Surface to Surface, In.	0.44	0.5
f.	Net Tank Volume, Gal.	40	280
g.	Ratio $\frac{f, \frac{gal}{d, ft.^2}}{}$	0.08	0.06
h.	Temperature, ^oF	50-68	39-67
i.	Average Influent BOD Concentration, mg/l	426	147

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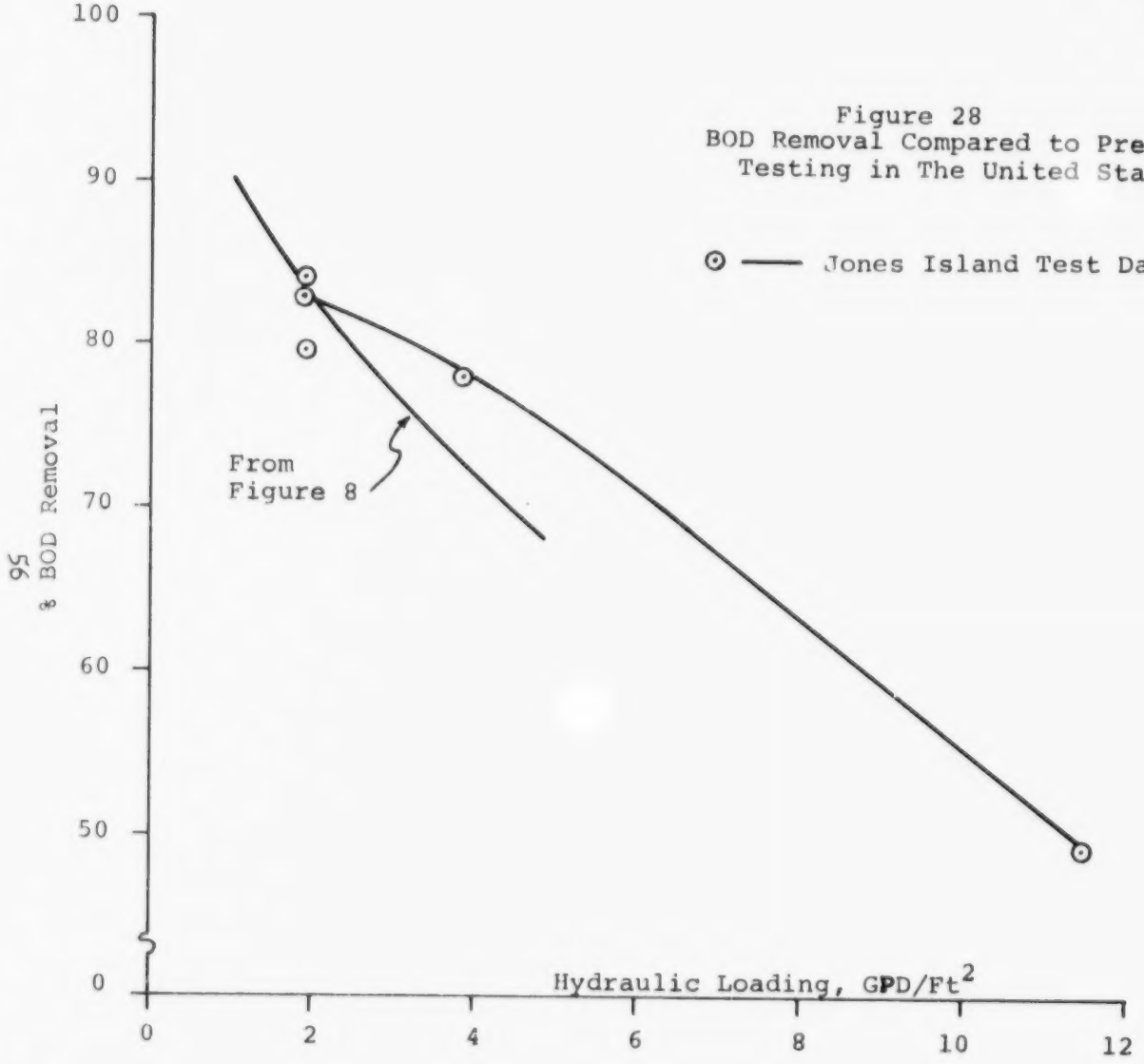


Figure 28
BOD Removal Compared to Previous
Testing in The United States

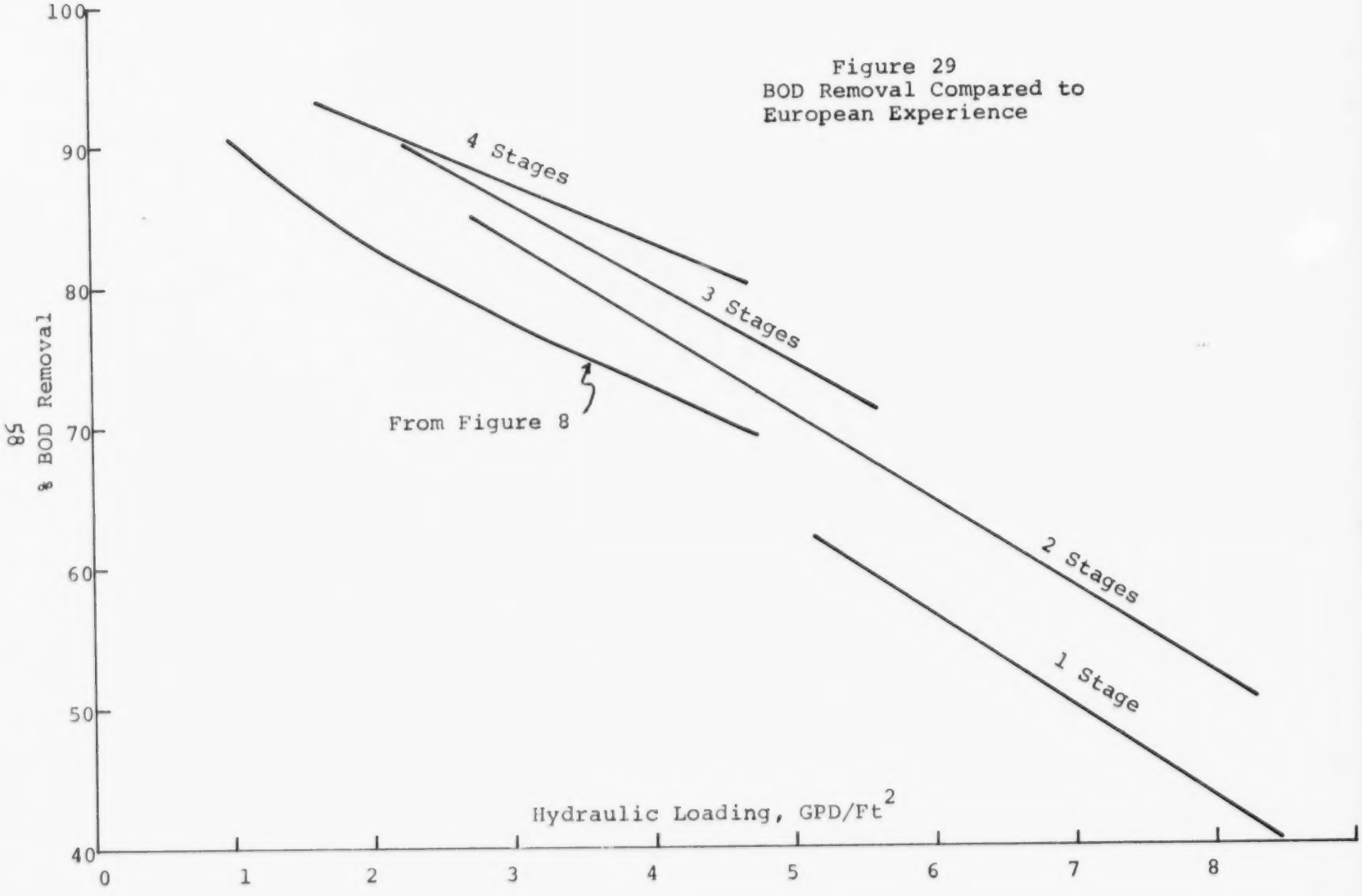
⊙ —— Jones Island Test Data

Another factor contributing to better performance by the Jones Island unit is a greater liquid-holding capacity per unit surface area. This means that at a given hydraulic loading in gpd/ft^2, the Jones Island unit had a longer retention time. The importance of liquid holding capacity per unit surface area is shown in Figure 29, where the performance curve from Figure 8 is compared to European experience with the rotating disc process.(4) European disc systems have 0.85 inch spaces, surface to surface, between discs, which, in contoured-bottom tankage, yields a liquid holding capacity of 0.085 gal/ft^2 of disc surface. The European experience on multistage disc systems also indicates that a 4-stage disc plant can be loaded at a 30% greater rate than a 2-stage plant and achieve the same degree of treatment. The reason for this is that the more favorable residence time distribution of a 4-stage system and the approximately first order BOD removal kinetics of the disc process increase the overall BOD removal rate.

The 400,000-gpd demonstration plant at Pewaukee, Wisconsin, is constructed in four stages and with 0.085 gal. liquid capacity per sq. ft. of disc surface, which will verify the treatment capacity experienced in Europe.

The correlation of disc speed with various treatment parameters has been done on the basis of revolutions per minute in this report. To utilize disc speed as a design criterion requires that a measure of disc speed common to all disc diameters be used. The peripheral or circumferential velocity is such a measure and, because it is also directly proportional to the average velocity of the disc surface area, strongly suggests that it be utilized as a design criterion. The Jones Island tests with 1.0-ft. diameter discs at 15-30 RPM, the tests reported here on 5.7 ft. diameter discs at 2-5 RPM and European experience with 10-ft. diameter discs at 1-2 RPM indicate peripheral speed to be a common design criterion. Tests at various disc speeds during the evaluation of the demonstration plant at Pewaukee will help verify peripheral velocity as a basic design criterion.

Figure 29
BOD Removal Compared to
European Experience



SECTION IX

COMPARISON TO OTHER PROCESSES

A complete comparison of the rotating disc process to other processes should include capital cost comparisons; but since this is beyond the scope of this investigation, the discussion will be limited to operating characteristics of the processes.

The rotating disc process is similar to the trickling filter process in that they are both fixed film biological reactors. There are some key differences, however, which give the disc process some important benefits. In the disc system, the biomass is passed through the wastewater rather than the wastewater over the biomass. This provides intimate contact of all of the organisms with the wastewater and prevents problems with clogging of the media by excess biomass. Shearing forces created by rotation at peripheral disc velocities of 30 to 60 ft/min continuously and uniformly strip excess biomass from the discs. Continuous wetting of the entire biomass also prevents development of the flies often associated with trickling filter operation.

Aeration with rotating discs is a very positive means of supplying sufficient dissolved oxygen to the attached biomass and prevents development of anaerobic conditions. Both the intensity of contact between the biomass and the wastewater and the aeration rate can be controlled simply by adjusting the rotational speed of the discs. This can be done to suit a particular wastewater and its treatment requirements.

Wastewater retention time can also be controlled by selecting an appropriate disc spacing and tank size. This allows much higher degrees of treatment to be obtained than in the trickling filter process where relatively short retention times are unavoidable. It is unnecessary to recycle effluent to achieve minimum wetting rates or aid in sloughing as in the trickling filter. This allows the disc process to take advantage of the benefits of staged operation, which would otherwise be destroyed by effluent recycle.

The rotating disc process is somewhat similar to the activated sludge process in that it has a suspended culture in its mixed liquor. However, the suspended culture is estimated to represent less than 5% of the total amount of biological solids on the discs and would therefore contribute only marginally to the treatment. Because of this, the disc process is not upset by variations in hydraulic or organic loading (5,6,7) as is the activated sludge process. Like the activated sludge process, the disc process does produce a sparkling clear effluent when operated at appropriate hydraulic loadings.

Two problems encountered in the operation of activated sludge treatment plants are start-up at flows much lower than design flow and operation during periods of very low flow. Operating a rotating disc plant at low initial flows or during periods of very low flow will yield effluents of higher quality than at design flow. During periods of no flow, effluent can be recycled at a nominal rate to maintain biological activity.(5)

Minimal operator attention and low power consumption are attractive features of the rotating disc process when compared to the activated sludge process, especially for package plant applications and for wastewater treatment needs in remote locations. Unlike the activated sludge process, the rotating disc process can be designed for any degree of treatment and the secondary sludge will settle well.

The rotating disc process lends itself well to upgrading existing treatment facilities. Because of its modular construction, low head loss and shallow excavation, it can be installed to follow existing primary treatment plants, including Imhoff tanks and septic tanks.

Many state regulatory agencies are requiring treatment plants to be designed to achieve various degrees of nitrification as well as BOD and suspended solids removal. To achieve this with the activated sludge process requires that the plant be constructed in at least two stages of aeration, settling and sludge recycle. The rotating disc process has demonstrated in this investigation that it can achieve any desired degree of nitrification with one settling tank and no sludge recycle.

A disadvantage to the disc process is the need for covering the discs to protect the biological growth from freezing temperatures and precipitation and protect the discs from wind damage and vandalism. For installations as large as 100,000 population equivalent in Europe, heating and forced ventilation of the enclosure have not been found necessary. European winters are not as severe as in the northern United States; so the demonstration plant at Pewaukee, Wisconsin, should demonstrate any need for heating or forced ventilation.

Although an enclosure is an additional expense for the disc process, aesthetic requirements for wastewater treatment facilities may dictate providing enclosures for all treatment processes in the near future.

In winter, a covered treatment plant will experience fog and condensation from water evaporating from the relatively warm wastewater. This will accelerate corrosion and create slippery footing within the enclosure. To avoid this problem with rotating disc plants, a semicircular shaped, insulated cover has been developed to be supplied, as an integral part of a disc assembly. It covers only the discs and drive components. Fog and condensation are restricted to the atmosphere surrounding the discs, and less treatment plant area needs to be covered.

SECTION X

ACKNOWLEDGMENTS

The support of David Kluge, Village Engineer for Pewaukee, Wisconsin is gratefully acknowledged.

The construction and operation of the test facility analytical work and report preparation were performed by a team from Autotrol Corporation, consisting of Ronald L. Antonie, Franklin J. Koehler,. Robert J. Hynek, Henry H. Homs, and Robert T. Baugh.

Appreciation is expressed for the support of the project by the Water Quality Office, Environmental Protection Agency, and the help provided by Dr. Robert L. Bunch, Project Officer.

SECTION XI

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SECTION XII

GLOSSARY

D.O.	Dissolved Oxygen
Effl.	Effluent
GPD	Gallons per Day
Infl.	Influent
mg/l	Milligrams per Liter
ML	Mixed Liquor
NH_3-N	Ammonia Nitrogen
N_k	Kjeldahl Nitrogen
NO_3-N	Nitrate Nitrogen
NO_2-N	Nitrite Nitrogen
Rem'd	Removed
RPM	Revolutions per Minute
Susp.	Suspended
Vol.	Volatile
SS	Suspended Solids

SECTION XIII

PATENTS AND PUBLICATIONS

No patents have been applied for as a result of work done during this project.

An oral presentation of the results of this project was made at the 43rd Annual Conference of the Water Pollution Control Federation, Boston, Massachusetts, October 4-9, 1970. Limited distribution of copies of the presentation has been made to individuals who specifically requested them.

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SECTION XIV

APPENDIX

PEWAUKEE TEST D[illegible] SUMMARY

CONTRACT 14-12-810

| MONTH, YEAR | | NOVEMBER 1969 | | |

PEWAUKEE TEST DATA SUMMARY

CONTRACT 14-12-810

| MONTH, YEAR | | |

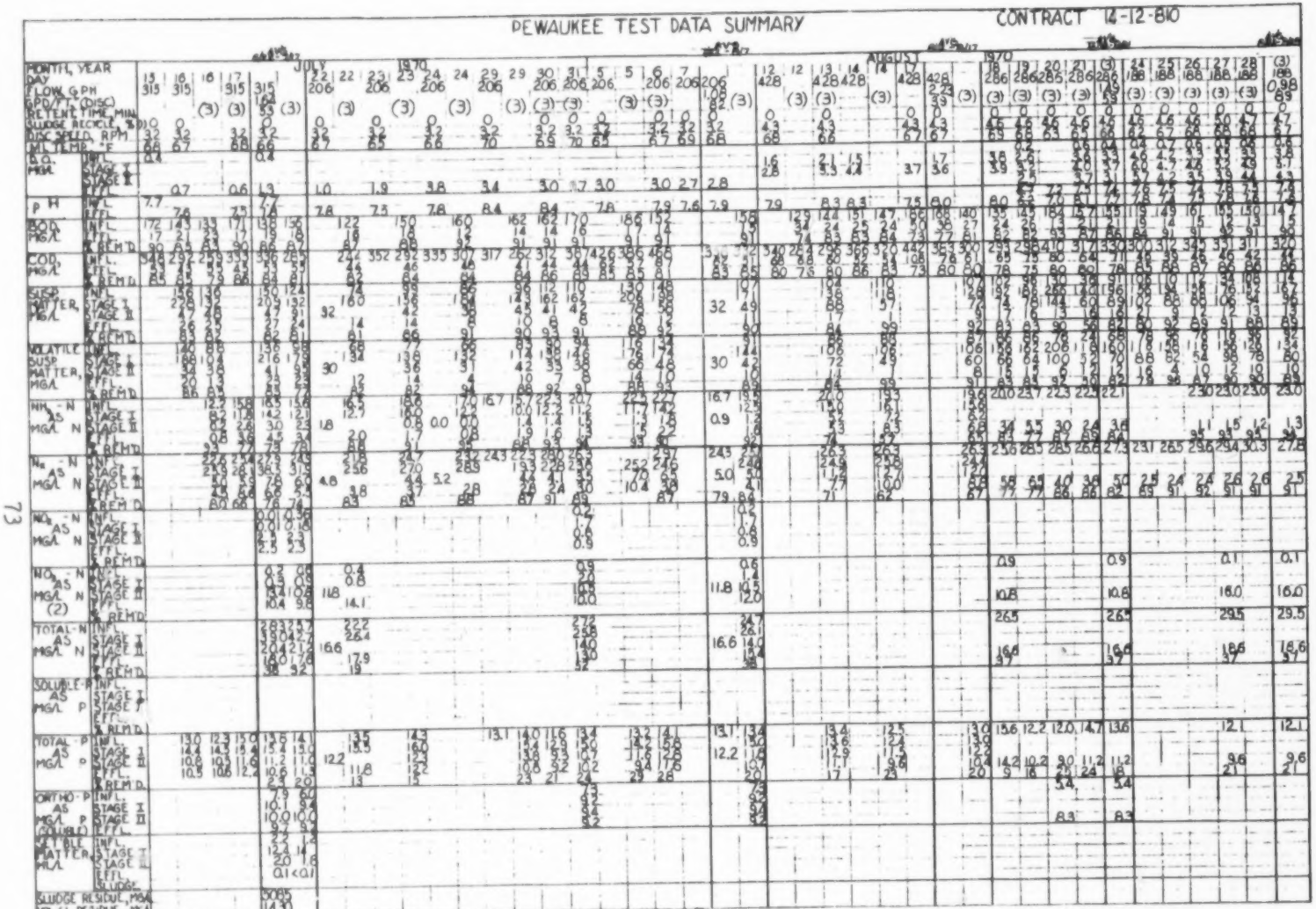
PEWAUKEE TEST DATA SUMMARY

CONTRACT 14-12-810

| MONTH, YEAR | | MAY 1970 AVG | | | | | | | | | | | | JUNE 1970 AVG | | | | | | | | | | | | | | | | | | JULY 1970 AVG | | | | | | | | | | | | | | | | | |

PEWAUKEE TEST DATA SUMMARY

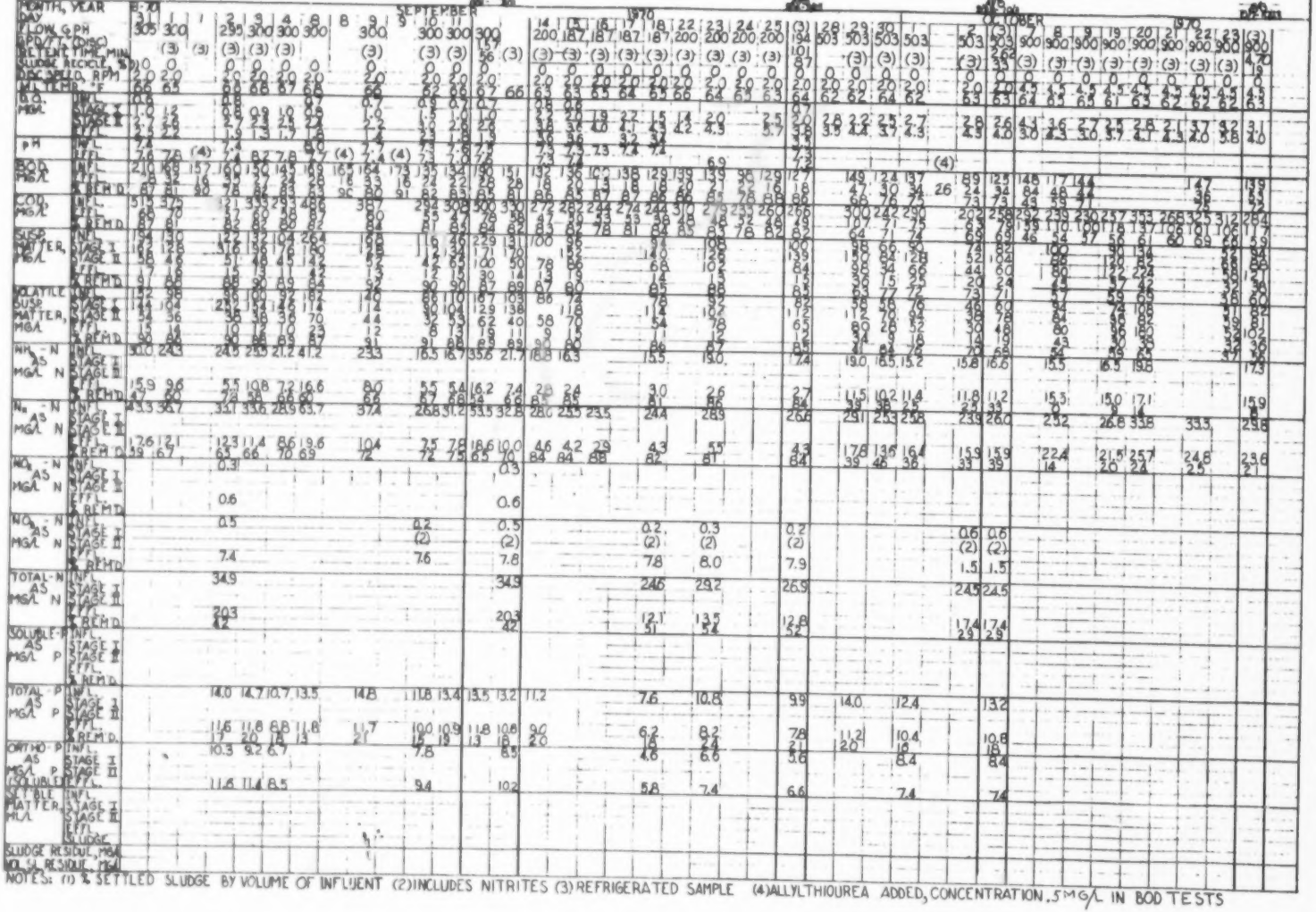
CONTRACT 14-12-810



NOTES: (1) % SETTLED SLUDGE BY VOLUME OF INFLUENT (2) INCLUDES NITRITES (3) REFRIGERATED SAMPLE

PEWAUKEE TEST DATA SUMMARY

CONTRACT 14-12-810



NOTES: (1) % SETTLED SLUDGE BY VOLUME OF INFLUENT (2) INCLUDES NITRITES (3) REFRIGERATED SAMPLE (4) ALLYLTHIOUREA ADDED, CONCENTRATION .5 MG/L IN BOD TESTS

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8. Performing Organization Report No.

7. Author(s)
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10. Project No.
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13. Type of Report and Period Covered

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15. Supplementary Notes

16. Abstract

A prototype package plant incorporating the rotating disc wastewater treatment process was tested on municipal wastewater at the Village of Pewaukee, Wisconsin, to evaluate its treatment capabilities and establish guidelines for operation and testing of a full-scale rotating disc demonstration plant soon to be put into operation at Pewaukee. The package plant included a rotating bucket feed mechanism, ninety-one 1.75-meter diameter discs divided into two stages, and a secondary clarifier with a sludge-removal mechanism. Variables tested included hydraulic loading, rotational disc speed, sludge recycle, and wastewater temperature as it varied with climatic conditions.

At a hydraulic loading of 1.5 gpd/ft^2 of disc surface, the package plant achieved 87% removal of BOD and 80% removal of suspended solids to yield an effluent of 20 mg/l BOD and suspended solids when treating effluent from the existing primary clarifier. At the same loading, 85% removal of ammonia nitrogen was obtained to yield an effluent of 3.5 mg/l.

Low maintenance requirements and low power consumption were demonstrated by the rotating disc process during the test program.

17a. Descriptors
Wastewater Treatment
BOD Removal
Nitrification

17b. Identifiers
BIO-DISC Process, Rotating Disc Process, Rotating Biological Contactor, Tauchtropkorper

17c. COWRR Field & Group

18. Availability

19. Security Class. (Report)

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